American Foundryman

★ THE FOUNDRYMEN'S OWN MAGAZINE

AUGUST 1946

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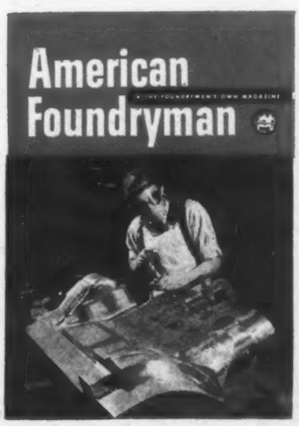

Completing a chipping operation on metal pattern, patternmaker wears a fac shield and cup goggles for protection again flying particles.

Photo courtesy Allis-Chalmers Mfg. C

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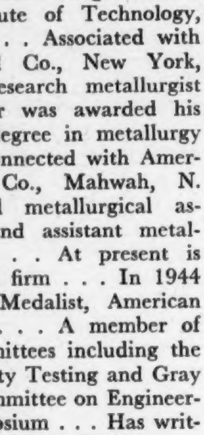
★ AUGUST WHO'S WHO ★

R. A. Flinn

Co-author, with H. J. Chapin, of the paper *"White and Gray Iron Ductility and Elasticity"* . . . Mr. Flinn obtained his Bachelor of Science degree in chemical engineering from College of the City of New York, New York City (1936) . . . One year later (1937) received his Master of Science degree from Massachusetts Institute of Technology, Cambridge, Mass. . . . Associated with International Nickel Co., New York, from 1937-39 as research metallurgist In 1941 the author was awarded his Doctor of Science degree in metallurgy from M.I.T. . . . Connected with American Brake Shoe Co., Mahwah, N. J., he was named metallurgical assistant (1941-42) and assistant metallurgist (1942-43) . . . At present is metallurgist for that firm . . . In 1944 was named Howe Medalist, American Society for Metals . . . A member of various A.F.A. committees including the Committee on Fluidity Testing and Gray Iron Division Subcommittee on Engineering Properties Symposium . . . Has written extensively for the industrial press and for various technical societies . . . Nature of subjects: damping capacity, age hardening, structural control of alloy iron and steel and other subjects . . . A charter member of the A.F.A. Metropolitan chapter . . . Member of A.F.A., ASM and SESA.

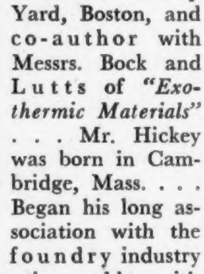


E. T. Myskowski

Born in Lowell, Mass., April 3, 1919 . . . A graduate of Missouri School of Mines, Rolla, Mo. . . . Received his Bachelor of Science degree in metallurgical engineering, 1941 . . . Became associated with the Naval Research Laboratory, Anacostia Station, Washington, D. C., as metallurgist upon graduating from college . . . Has written papers dealing with manganese alloys and manganese bronze for various technical societies . . . Was co-author of a paper on manganese bronze presented at the 1943 A.F.A. convention . . . In this issue is co-author, with H. F. Taylor, of the paper *"Skimmer Screens for Non-Ferrous Castings"* . . . Holds membership in A.F.A. and ASM.

J. P. Hickey

Master molder, U. S. Naval Ship Yard, Boston, and co-author with Messrs. Bock and Lutts of *"Exothermic Materials"* . . . Mr. Hickey was born in Cambridge, Mass. . . . Began his long association with the foundry industry in 1907 as an apprentice molder with Blake-Knowles Pump Co., Cambridge . . . After serving his four year apprenticeship, he became affiliated with Hunt-Spiller Mfg. Co., Boston, in 1912, as molder . . . From 1914-26, Mr. Hickey was connected with various foundries in and around Boston as a molder . . . From 1926-36 was leadingman and planner, U. S. Naval Ship Yard, Boston . . . In 1937 was named master molder, the position he holds at the present time . . . Technical writings include co-authorship of a paper on low-carbon steel . . . A member of A.F.A.



H. J. Chapin

"White and Gray Iron Ductility and Elasticity," written by R. A. Flinn and Mr. Chapin, is presented in this issue . . . Mr. Chapin was born in 1908 . . . Graduated from Haverford College, Haverford, Pa., (1929) and Massachusetts Institute of Technology, Cambridge, Mass. (1932) . . . Began his affiliation with the castings industry during school summer vacations, being associated with Midvale Co., Philadelphia . . . From 1933-37 was a member of the metallurgical department, Carnegie-Illinois Steel Corp., Duquesne, Pa. . . . Was appointed foreman of the laboratory in 1937 . . . Joining the United States Steel Corp., Kearney, N. J., in 1937 he was a member of the research laboratory . . . Was connected with Peck, Stow and Wilcox Co., Southington, Conn., (1939-42) as metallurgist . . . Since 1942 has been a staff member, metallurgical laboratory, American Brake Shoe Co., Mahwah, N. J. . . . A member of A.F.A. and ASM.

Dr. V. Paschkis

Dr. Victor Paschkis presents a discussion on *"Heat Treating Furnaces"* . . . The author was born in Vienna, Austria . . . Higher education obtained from Institute of Technology, Vienna . . . In 1921 received his M.E. degree and in the two succeeding years was awarded his E.E. and D.Sc. degrees . . . From 1922-38 worked with various European companies, including some years as a consulting engineer . . . Coming to the United States in 1938 he began his industrial career with A. F. Holden Co., New Haven, Conn., as head of the furnace department . . . The following year (1939) was connected with Ajax Electric Co., Philadelphia, as research and design engineer . . . Joined the staff of Columbia University, New York City, in 1940, and at present is in charge of heat and mass flow analyzer laboratory . . . Has written for the trade press and for meetings of technical societies both in the states and abroad . . . Subjects include heat flow and electric furnaces . . . A member of the Electro-Chemical Society.

Michael Bock II

Co-author of the current article on *"Exothermic Materials"* . . . Paper was written jointly by Messrs. Bock, Hickey and Lutts . . . Mr. Bock was born in Buffalo, N. Y. . . . Attended Lehigh University, Bethlehem, Pa., from 1935-39 and obtained his Bachelor of Science degree in metallurgical engineering . . . Affiliated with Republic Steel Corp., Buf-

falo (1939-40), as foundry technical observer . . . Was metallurgist, U. S. Naval Ship Yard, Boston, from 1940-45 . . . At present is metallurgical engineer with Unexcelled Chemical Co., Cambridge, Mass. . . . Besides his membership in A.F.A., Mr. Bock is associated with AIME, ASM, ASTM, Steel Founders Society of America and American Industrial Radium and X-Ray Society.

G. A. Pealer

Born February 6, 1897, in Emporium, Pa., Guy A. Pealer came in contact with the foundry industry during 1917 . . . Affiliating with the Elmira Foundry Co., Elmira, N. Y., Mr. Pealer became a patternmaker... In 1930 he assumed his present position with the Elmira Foundry Co. as pattern superintendent... The author's discourse, which is published herein, covers *"Patterns in a Production Foundry"* . . . Member of the American Foundrymen's Association.

J. J. Clark

See his article in this issue: *"Malleable Foundry Core Sand Practice"*... Born in Royal Oak, Mich., on the first day of August, 1909 ... Received his Bachelor of Science degree from Michigan State College of Agriculture and Applied Science, East Lansing, Mich., in electrical engineering, 1931... Has been associated with Saginaw Malleable Iron Division, General Motors Corporation, Saginaw, Mich., since 1932... Started as a chemist and in 1936 was made a draftsman ... One year later was assigned to the metallurgical department and at present is assistant metallurgist... Saginaw Valley chapter reporter and a member of that chapter's Board of Directors... Member of ASM and A.F.A.

H. J. Rowe

H. J. Rowe, Aluminum Co. of America, Cleveland, is well known in the technical world for his work on aluminum and its alloys . . . In this issue, Mr. Rowe and W. E. Sicha are co-authors of the paper *"Cast Aluminum Alloys Heat Treatment"* . . . Mr. Rowe was born in Cleveland . . . Is a graduate of Case School of Applied Science, Cleveland, where he specialized in physics . . . In 1927 he became affiliated with the Aluminum Co. of America, where he has remained ever since . . . Worked in the technical control and development section but at present is chief metallurgist, casting division . . . Has presented numerous papers to A.F.A. on subjects relating to the founding of aluminum alloys . . . Has contributed frequently to the trade press . . . An active A.F.A. Aluminum and Magnesium Division worker . . . He is a member of the Division's Executive Committee; Committee on Sand Castings; Committee of Review of A.F.A. Handbook; Committee on Centrifugal Castings; Test Bar Committee and chairman, Alloy Recommendation Committee . . . A member of A.F.A.

W. E. Sicha

See: *"Cast Aluminum Alloys Heat Treatment"* . . . Written jointly by H. J. Rowe and W. E. Sicha . . . Mr. Sicha obtained his Bachelor of Science degree in metallurgical engineering from Case School of Applied Science, Cleveland . . . Received his Master of Science degree from University of Michigan, Ann Arbor . . . After completing his scholastic studies he joined Aluminum Co. of America in 1929 . . . Was appointed magnesium foundry superintendent and at present is research metallurgist, Cleveland research division . . . A member of A.F.A.

C. G. Lutts

A co-author of the paper *"Exothermic Materials"* with Messrs. Bock and Hickey . . . Mr. Lutts was born in Massachusetts in 1891 . . . A graduate of the University of Maine, Orono (1913), he was awarded a Bachelor of Science degree in chemistry . . . Following graduation was associated with General Electric Co., Lynn, Mass., as chemist . . . Was a member of the British Purchasing Commission during 1916-17 and was located in Pittsburgh, Pa. . . . Has been with the U. S. Naval Ship Yard, Boston, since 1917 as metallurgist and materials engineer . . . A frequent writer for the trade press and for various technical societies . . . Nature of subjects include chemical analysis, x-ray inspection and testing methods and procedures . . . Holds membership in the following technical societies: AIME, ASM, ASTM, American Chemical Society and American Industrial Radium and X-Ray Society.

H. F. Taylor

Co-author, with E. T. Myskowski, of *"Skimmer Screens for Non-Ferrous Castings"* . . . Mr. Taylor was born in Leslie, Mich. . . . Received his Bachelor of Science and Master of Science degrees from Michigan State College of Agriculture and Applied Science, East Lansing . . . At present research associate at Massachusetts Institute of Technology, Cambridge, he was formerly of the Naval Research Laboratory, Washington, D. C. . . . Started his career with the Michigan State Highway Department as a clerk . . . Was associated with Michigan State College, foundry department, as molding instructor and was later appointed instructor in the metallurgy department . . . Became affiliated with the Michigan Sugar Co., Lansing, and shortly thereafter joined the Naval Research Laboratory staff . . . Was presented the first Peter L. Simpson award at the 50th Anniversary A.F.A. Convention "for his unfailing interest in and contributions to foundry research" . . . Has served on numerous A.F.A. committees . . . Is a well known technical speaker and his findings have been published by the trade press here and abroad . . . Has served as a director, vice-chairman and chairman of the Chesapeake chapter . . . Is a member of A.F.A., AIME, ASM, Institute of Metals (British), Society of Naval Engineers and Washington Society of Engineers.

Committee Report

Due to war conditions the activities of the A.F.A. Steel Division Committee on Heat Treatment of Steel Castings were greatly curtailed . . . Since 1944 the principal object of this committee has been a survey of the use of the end-quench (Jominy) test in the steel foundry industry . . . Committee has reported herein some developments in the field of heat treatment . . . See: *"Heat Treatment of Steel Castings"* . . . Also reported is the results of a survey to determine the acceptance by the foundry industry of the end-quench test for hardenability . . . Personnel of the Committee of Heat Treatment of Steel Castings is as follows: E. R. Young, *chairman,* Climax Molybdenum Co., Chicago; N. A. Birch, American Brake Shoe Co., Mahwah, N. J.; H. H. Blosjo, Minneapolis Electric Steel Castings Co., Minneapolis; Werner Finster, Reading Steel Casting Div., American Chain & Cable Co., Reading, Pa.; R. A. Gezelius, General Steel Castings Corp., Eddystone, Pa.; and C. T. Greenidge, Battelle Memorial Institute, Columbus, Ohio.

PRESIDENT WOOD PAYS TRIBUTE TO MEN WHO MADE FOUNDRY PROGRESS POSSIBLE

THE AMERICAN Foundrymen's Association has just celebrated its Golden Jubilee with a magnificent exhibition of foundry materials and equipment, and with many technical sessions led by the most outstanding foundry technicians of the world.

This historic event marked the culmination of a cooperative effort by leaders of the industry 50 years ago when "the hand was master of the craft" and trade secrets generally were jealously guarded by their possessors.

Those broad-minded leaders realized that if their craft was to develop, it must be advanced through unity of purpose and a sharing of experience and skills between fellow workers.

They "builded better than they knew" until today, in 1946, there has grown from this small group of pioneer leaders an association of nearly nine thousand members grouped into 33 chapters all over North America.

Working together for mutual benefit, the members include noted scientists, celebrated technicians, engineers, research men, writers, publishers, material suppliers, equipment manufacturers, trade association leaders, operators, students, apprentices, and skilled tradesmen . . . all volunteering their time and experience for a common cause. This in addition to a staff working diligently to broadcast new discoveries and to stimulate new research that all may benefit from carefully recorded progress and reliable data.

Reviewing the history of the foundry industry over the past fifty years cannot but impress one with the great contribution that has been made over these years by the membership of this organization through its individuals, committees and chapters. We should pause, therefore, to pay tribute to those men who have so earnestly worked for the betterment of our industry.

We have come out of the war with a fine record of accomplishment. We are facing a great future with new techniques, new skills and new men. Unusual opportunities are in the offing for our industry.

Never before have we had such an opportunity for development.

Never before have we had so many trained men and technicians in the industry.

Never before have we had so large and active a membership.

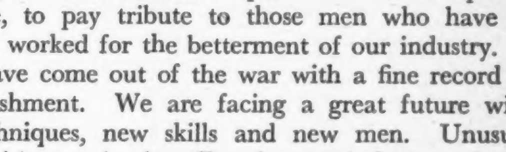
Never before have we had such enthusiasm among our members and Chapters.

Never before has A.F.A. been so well prepared financially to serve.

Never before has it been so universally acknowledged that a man is not whole-heartedly in the foundry business until he is a member of A.F.A.

The foundry industry now is beginning to move. We are shaking the sand out of our shoes.

The Foundry is a GOOD place to work.



S. V. WOOD, *President,*
AMERICAN FOUNDRYMEN'S ASSOCIATION.

S. V. WOOD, president and manager, Minneapolis Electric Steel Castings Co., Minneapolis, Minn., is president, American Foundrymen's Association. A graduate of the University of Minnesota, Minneapolis, he entered the castings industry in 1913. Mr. Wood was active in the formation of the Twin City Chapter, A.F.A., and served as a chapter director. Has served a three-year term as a National Director and in 1945-46 was National Vice-President. Is well known to the Association membership for his sincere belief in the foundry industry and his faith in its future.

CHAPTER CHAIRMEN

MEET IN CHICAGO

MEETING AT the Stevens Hotel, Chicago, July 24-25, for the Third Annual Chapter Chairman Conference, over 35 chapter officers, directors and delegates carried away with them some new and improved ideas concerning the conducting of chapter affairs for the forthcoming year. This 2-day session was called for the purpose of discussing closer relations between national and local activities, so as to coordinate activities on behalf of the entire foundry industry.

National Vice-President Max Kuniansky, Lynchburg Foundry Co., Lynchburg, Va., as Chairman, Chapter Contacts Committee of the National Board of Directors, acted as presiding chairman at the meeting. Other National Officers who attended were:

President S. V. Wood, Minneapolis Electric Steel Castings Company, Minneapolis, Minnesota.

Director and Past President Fred J. Walls, International Nickel Co., Detroit.

Director E. W. Horlebein, Gibson & Kirk Co., Baltimore, Md.

Director S. D. Russell, Phoenix Iron Works, Oakland, Calif.

Past Director Wm. B. Wallis, Pittsburgh Lectromelt Furnace Corp., Pittsburgh, Pa.

Guests included: Dr. Henry T. Heald, President, Illinois Institute of Technology, Chicago, guest speaker at the Conference dinner, July 24; Frank G. Steinebach, *The Foundry*, Cleveland; and George Rauen, Olympic Foundry Co., Seattle, Wash.

All but one of the 32 active A.F.A. chapters were represented at this meeting. The Mexico City chapter representative was unable to attend due to circumstances beyond his control. The inactive Minnesota University Student chapter, which suspended operation for the duration, has not begun to function as yet. Four chapters (Eastern Canada and Newfoundland, Northern Illinois and Southern Wisconsin, Central Illinois and Central Ohio) sent additional delegates at their own expense to benefit from the discussions. Chapter officers who attended were:

Birmingham—Chairman Tom Benners, Jr., T. H. Benners & Co., Birmingham, Ala.

Canton—Chairman I. M. Emery, Massillon Steel Casting Co., Massillon, Ohio.

Central Illinois—Chairman Zig Madacey, Caterpillar Tractor Co., Peoria, Ill.

Central Indiana — Chairman J. P. Lentz, International Harvester Co., Indianapolis.

Central New York—Chairman E. E. Hook, Dayton Oil Co., Syracuse, N. Y.

Central Ohio—Chairman N. J. Dunbeck, Eastern Clay Products, Inc., Eifort, Ohio.

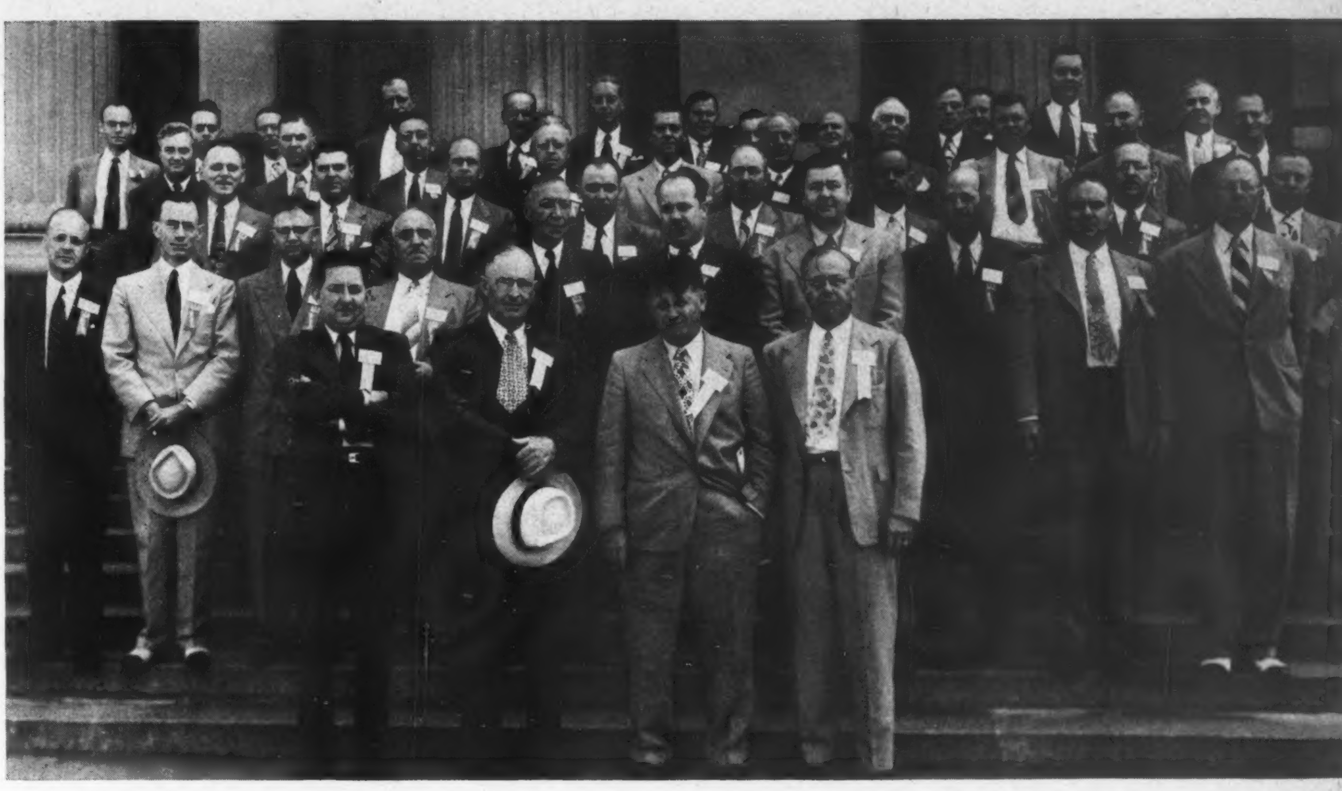
Chesapeake—Chairman David Tamor, American Chain & Cable Co., York, Pa.

Chicago — President L. H. Hahn, Sivyer Steel Casting Co., Chicago.

Cincinnati — Chairman J. S. Schumacher, Hill & Griffith Co., Cincinnati.

Detroit—Chairman A. H. Allen, *The*

Chapter representatives, National Officers, National Headquarters staff members and guests seated around the tables at the Third Annual Chapter Chairman Conference held in Chicago, July 24-25.



Photograph taken before visiting the Museum of Science and Industry, Chicago, where the chairmen viewed the model operating foundry sponsored jointly by the National Office and the A.F.A. Chicago Chapter.

Foundry, Penton Publishing Co., Detroit.

Eastern Canada & Newfoundland—Vice-Chairman A. E. Cartwright, Robert Mitchell Co., Ltd., Montreal, Que.

Metropolitan—Chairman H. L. Ullrich, Sacks-Barlow Foundries, Inc., Newark, N. J.

Michiana — Chairman John McAntie, Covel Mfg. Co., Benton Harbor, Mich.

Northeastern Ohio—President Henry Trenkamp, Ohio Foundry Co., Cleveland.

Northern California—President Richard Vosbrink, Berkeley Pattern Works, Berkeley, Calif.

Northern Illinois & Southern Wisconsin—Chairman John Doerfner, Jr., Gunite Foundries Corp., Rockford, Ill.

Northwestern Pennsylvania—Chairman Earl Strick, Erie Malleable Iron Co., Erie, Pa.

Ontario — Chairman J. A. Wotherspoon, Anthes-Imperial, Ltd., St. Catharines, Ont.

Oregon — Secretary-Treasurer F. A. Stephenson, Dependable Pattern Works, Portland, Ore.

Philadelphia—Chairman B. A. Miller, Cramp Brass & Iron Foundries Div., Baldwin Locomotive Works, Philadelphia.

Quad City—Chairman C. S. Humphrey, C. S. Humphrey Co., Moline, Ill.

Rochester—President Walter G. Brayer, Bausch & Lomb Optical Co., Rochester, N. Y.

Saginaw Valley — Chairman John F. Smith, Chevrolet Grey Iron Foundry, Saginaw, Mich.

St. Louis—Chairman Roland T. Leisk, American Steel Foundries, East St. Louis, Ill.

Southern California—President W. D. Emmett, Los Angeles Steel Castings Co., Los Angeles.

Texas—Vice-Chairman L. H. August, Hughes Tool Co., Houston.

Toledo—Chairman B. L. Pickett, Unitcast Corp., Toledo, Ohio.

Twin City—Chairman H. M. Patton, American Hoist & Derrick Co., St. Paul, Minn.

Western Michigan—Vice-Chairman C. H. Cousineau, West Michigan Steel Foundry Co., Muskegon, Mich.

Western New York—Chairman H. C. Winte, Worthington Pump & Machinery Corp., Buffalo, N. Y.

Wisconsin — President David Zuege, Sivyer Steel Casting Co., Milwaukee.

In his introductory remarks Vice-President Kuniansky stated that this meeting afforded the chapter chairmen to meet each other and exchange ideas, as well as learn something about A.F.A. President Shelly Wood welcomed the chapter officers to the meeting and Past President Walls followed with a brief outline and historical review of A.F.A.

Chapter Programs

The 2-day Conference opened on Wednesday, July 24, with 50 people in attendance, including members of the National Office staff and National Officers and Directors. Most of the morning was spent discussing ways and means of building better chapter programs. The importance of chapter programs was emphasized by National Secretary W. W. Maloney. A recommended five point program was outlined by the Secretary as follows:

(1) Carry out a chapter educational program conforming to the National Educational Program and local chapter conditions;

(2) Keep chapter activities before the local foundry industry and the general public through constant and frequent publicity efforts;

(3) Carry on sound, continuous membership work to further broaden the scope and importance of foundry technical activities throughout the industry;

(4) Arrange and conduct chapter programs of consistently high quality and of maximum value to the members; and

(5) Promote close cooperation between the chapter and the engineering societies, and between the chapters themselves, for exchange of information of mutual benefit and value.

The afternoon session was held at the Museum of Science and Industry, Jackson Park, Chicago, following an extensive tour of various museum exhibits. Highlight of the tour was the opportunity afforded the chairmen to see the model oper-

(Concluded on Page 46)

THE FUTURE AS FORECAST BY TWO

THE FOUNDRY OF THE FUTURE

AS SEEN IN 1902

Dr. Richard Moldenke
Secretary, A.F.A.
New York

LITTLE THOUGHT is given to the future of our industry in these brisk times of orders in plenty. Our plants are yet crowded to their full capacity. Enlargements have been the rule up to now, but the projection of new enterprises has practically ceased. The only possible exception is in connection with established plants. This, then, seems the time to analyze the conditions which will affect the future of the foundry industry to a greater or less extent.

In general, we may say that specialization has become the order of the day. At the present time, at least three quarters of the foundry output goes into channels within fixed and narrow bounds. This condition is not only likely to continue, but will become the national trade necessity.

Exports Important

Specialization as against generalization is the sharp contrast we note in comparing our industrial system with that of Europe. Everyone following out his own line of production to the extreme, learns the fine points which enable him to undersell at a profit. With our natural resources and transportation facilities, it is easy to see that careful nursing of the foreign trade we now enjoy should do much to mitigate the disasters of the hard times to come.

With the tendency toward standardization of everything within reach, the future seems to indicate a still firmer grip for us upon the commerce of the world, and as specialization of effort is really the cause of our world power, I cannot think otherwise than that specialization and standardization together should be the keynote for our industry for the future.

Price Outlook

Looking over the likely condition of the money market, it seems as if competition for work will sharpen considerably. Founders who have made connections which secure them preferences in the way of holding work will be compelled to drop prices in spite of this, the outsider naturally leading the procession. Every founder will therefore try to get hold of something he can do better and cheaper than his fellow townsman.

Some will succeed in this and keep their identity intact. The stronger ones will, however, be gradually drawn into working agreements with others in their line. From this, actual combination is but a short step.

This tendency, which has made our present time one of huge industrial combination, will be still more accentuated in the future. Self defense will compel closer business relations so far as it affects the buying of materials from the great combination of other industries, and similarly the selling to the great combinations of still other industries. With these conditions properly balanced, and sufficient "independents" to make things interesting, there is not the same chance of extreme disasters in our industrial economy as heretofore.

We may therefore look for combinations in the heavy lines of foundry work, such as in car wheels, ingot molds, rolls, malleables, stoves and radiators, electrical work, and special lines of machinery. We already have working agreements, small combinations, and plans for larger ones in our industry. The tendency is therefore plain enough to see, and it will result in material changes in the actual operation of the plants.

There is a general feeling of confidence in industrial ventures, as reflected by the market for securities. Wall Street, ever discounting the future, is getting ready to list more and more industrial ventures of approved character and vast proportions, and thus facilitates the purchase and sale of securities in a bona

(Continued on Page 23)

In 1903 the then Secretary of A.F.A. looked broadly at the foundry industry and considered the money market, Wall Street, labor, legislation, capital and international trade . . . as well as some practical foundry problems. His paper, presented at the Boston convention in 1902, indicates that A.F.A. had not yet found its true and recognized place as a technical society with sharply defined (and adhered to) objects. Of particular interest are the comments on specialization and standardization, on continuous cupola operation, and the use of molding machines and conveyors (then relatively new tools) and the need for apprentices.

Reprinted from JOURNAL of A.F.A., 1902-1903, vol. XI, pp. 111-118.

FOUNDRYMEN . . . . 32 YEARS APART

THE FOUNDRY OF 1950

AS VISUALIZED IN 1935

Fred J. Walls
International Nickel Co.
New York

CHANGE IS ONE of the things of which we are absolutely sure. The foundry of today will be different tomorrow. It is a simple matter for all of us to look back 15 years and comprehend the progress that has taken place in the art of founding, but not one of us is capable of definitely foretelling what the science of founding will be 15 years hence.

Founding used to be an art surrounded with mysteries and fortified by the secrets of men (molders and melters) who held them back for fear that their neighbors would become more proficient and steal their jobs. We have passed from the stage wherein personal experience was the only factor in success, to the stage of scientific control of materials and processes. Both the practical man and the technical man must realize that the other man's contributions are of equal importance in this progress if this visionary foundry shall become an actuality.

There seems to be a natural law that regulates the advance of science. Where only accidental observations can be made, the growth of knowledge creeps, but where organized laboratory experiments can be carried on, knowledge leaps forward. Research today becomes the beacon of tomorrow.

Location of Importance

With these thoughts in mind, I will attempt to describe my conceptions of a foundry in 1950. First of all, we must have a location for this foundry. Transportation and availability of materials will not be primary factors, but rather labor and living conditions which are bound to be more favorable in decentralized localities.

There is plenty of non-productive soil, most of which is already plotted and grown up with weeds, on some of which the 1950 foundries will be built. There is no question but that in a large majority of cases it will be found more economical to construct new buildings than attempt to revamp existing foundries to conform to regulations that will be enacted with respect to the sanitation and health protection for labor.

Foundries will probably be grouped under four general headings: Specialty (one commodity, such as piston rings); general jobbing (small quantities); production jobbing (large quantities); corporation foundries (complete lines).

Of course, there will always be in existence small jobbing foundries making castings which do not require special properties. It will be impossible for any one person to become sufficiently posted on all the scientific problems involved in foundry processes, thus making it necessary to employ a group of specialists technically trained in the various sciences.

Control Costs

This increases overhead expense, and inasmuch as economy will be the watchword in 1950, just as it is now, there must be volume over which to spread this additional cost. Thus it will be seen that the specialty foundry, where possibly one man can control the variables, and the larger jobbing production foundry, where several specialists are necessary and over which there is a larger volume to carry the burden, will be the foundries of 1950.

The 1950 foundry will be air conditioned. There will be improved metal and sand handling equipment. Instead of the necessity for sweeping of floors and gangways by the present broom method, permanently installed vacuum systems will keep all departments free from dirt and dust. There will be automatically controlled lighting units regulated by photo-electric cells and a great many other devices to eliminate the variables involved in the human element.

Waste, such as cupola heat loss up the stack, slags, sand, refractories, indirect supplies, and especially unnecessary cleaning operations in

Contrast these forecasts of 1935 with those of 1903—both by prominent A.F.A. figures. Many of the predictions of past President Walls have already been realized; others still are developing slowly. Triplexing is well established; the Bessemer converter is being re-examined; the importance of foundry control is widely accepted; synthetic binders now are receiving greater attention; dust control is of major interest to thinking foundrymen; directional solidification is the subject of intense study; permanent molding and centrifugal casting have lived up to predictions. Both writers, in 1902 and 1936, stress importance of the foundryman.

Reprinted from *The Iron Age,* June 13, 1935.

castings, will have been cut to a minimum by new equipment and a better understanding of the physical and chemical reactions of the materials and combinations of materials entering into operations and processes.

Raw materials, metals, fuels, fluxes, refractories and certain of the indirect supplies will have new specifications and characteristics, with a resulting better understanding between supplier and consumer. For example, the pig irons and all of the virgin metallic alloys and their inherent non-metallics will be controlled through spectroscope, x-ray, high-power microscopes and electroanalysis.

We will have proved by 1950 that the physical properties of cast metals are not primarily controlled by the five principal metalloids, namely, carbon, silicon, sulphur, phosphorus and manganese, as at present, but that the non-metallics and the traces of other elements and their combinations are the essential factors in the control of desired properties.

Alloys Better Understood

Alloys, such as chromium, nickel, molybdenum, etc., are bound to become better understood by 1950 than at present. I do not think it is too bold to prophesy that the foundryman who does not become alloy-minded will be non-existent.

The virtues of alloy cast irons versus other structural materials for definite applications have scarcely been touched upon. I refer in particular to the vibration damping effect or "dynamic ductility" as expressed by Von Heydekampf. Other virtues are fatigue properties, freedom from "notch effect," corrosion and heat resistance, and resistance to thermal shock. All of these features will be definitely established in the higher alloy compositions during the next 15 years.

How will we be melting or processing these alloys in 1950? Personally, I think the cupola will continue to maintain its prominence. There will be radical changes in this type of melting unit as we more intelligently understand what really takes place within its various zones and our knowledge develops with respect to the five things that enter into its operation: that is, refractories, fuels, fluxes, metals and air.

In order to understand more thoroughly what has taken place within the cupola, we must study not only the product sought, but the by-products developed in the process. There are two by-products—gases and slags—both of which will be considered as important in successful operation as materials charged.

More Efficient Cupola

I can visualize the cupola of 1950 melting twice the present rates per hour for the same size unit and with higher efficiencies than cupolas today. This will be brought about by several changes in construction, such as water cooling, high temperature zones, improved refractories and improved tuyere designs. By processing the air supply, such as drying, preheating and possibly enriching the oxygen content; we will double the melting rates.

Improved coke with respect to burning rate, ash conditions, sizing, etc., will also have a great influence not only in increasing the efficiency and capacity, but also in controlling the carbon content and quality.

My guess is that we will operate a cupola more along the lines of a blast furnace over long periods of time, without the daily dropping of the bottom and necessary repairs.

Electric furnaces as used today, both the indirect and the direct arc types, will continue to find new applications not only for cold melting and duplexing, but for triplexing and as a means of maintaining uniform high temperatures where a continuous uninterrupted supply of molten iron is necessary.

The induction type of electric furnace also will have established itself in the 1950 foundry. Powdered coal-fired furnaces, air furnaces and crucible furnaces will be employed for definite applications.

Triplexing Established

There is one refining unit, the Bessemer converter, which unquestionably will find its way into the gray iron foundry by 1950. At that time we will be triplexing large quantities of metal, from the cupola into the Bessemer, and then into the electric furnace where the necessary alloying and superheating will be completed.

In the molding division of the 1950 foundry, we may expect even more changes than have taken place during the last 20 years. Synthetic refractories and binders and the technical control of their properties will be a certainty, and with this control established, there will follow new methods of sand handling and molding. Closed conveying systems from conditioning units to mold blowing machines is one possibility.

Mathematical formulas for venting, gating, mold hardness and pouring temperatures will be available to the foundry executive. The same is true with respect to core-making methods and core sand mixtures. New developments in core binders, possibly air drying, will eliminate expensive equipment for drying and handling.

In laying out a progressive system for the 1950 foundry, one must keep in mind ideal working conditions for the laborer. Consequently, after we have the mold properly fitted with cores ready for pouring, we will convey it into a separate pouring and cooling room where adequate ventilation and air conditioning are provided. After cooling, it will pass on to the shakeout and then to the cleaning rooms.

Casting Cleaning

The cleaning of castings made in the 1950 foundry should be comparatively easy. There will be no reason for sand burning where properly prepared refractories are used. Excessive grinding, due to swells, fins, cutting, etc., should be a thing of the past.

In addition to the ordinary methods of molding, there will be a wider application of the new methods, more particularly the permanent or metal mold process, the centrifugal casting process and the pressure casting process. I believe that permanent molding will have developed by 1950 to an extent where complicated castings with undreamed of properties will be made by this method.

By the use of alloys, by taking advantage of the self-forging effect and by solidification rate control, we will be able to produce castings with closer mechanical tolerances and physical properties than at present. The centrifugal and pressure methods will also be used more extensively. Alloys which do not lend themselves readily to sand castings will be made by these methods, facilitated by means of controlled atmospheres within the molds.

The hit-and-miss methods of heat treating castings as practiced today will give way to a science controlled by technically trained men. I look

for real developments beginning with the moment that a mold is filled with molten metal and progressing with the casting into the finished product. By 1950 directional solidification will be a reality.

There will be special applications of the induction hardening methods, and other localized treatments to develop special properties will be common practice. Long cycle malleabilizing operations will have been reduced to at least one-tenth the present time.

A discussion of the foundry of 1950 would not be complete unless we also express our conception of the 1950 foundryman. It is apparent that a good foundry executive will require a thorough knowledge of chemistry and physics, or perhaps better still, physical chemistry.

Our colleges will be required to prepare men to fill these positions. The foundry has been frowned upon by graduates as an undesirable place to work. By 1950 this illusion will have disappeared and the technical man will realize that there is as much, if not more, science involved in producing good castings as in any other single branch of industry.

The foundry of 1950 will be an institution wherein science will play an important part along with experience. The continued efforts of large research groups and colleges will be the beacons to guide us in attaining our conceptions of the ideal foundry 15 years hence.

FOUNDRY OF THE FUTURE

(Continued from Page 20)

fide way, where formerly it did so only for dynamiting purposes. While this may not be a good thing for our industry, as it usually means a lot of injected water and shaky financiering, yet it is a distinct gain to the country at large in affording wider channels for monetary interchange, and the direct necessity for capturing the foreign markets for the enormous production by capital which must earn dividends.

The result of all this is very far reaching, and is perhaps best seen in the last factor of the problem—the extreme pressure in our navy and ship building yards, and this brings us to the third item in the discussion—the labor problem.

We are undoubtedly going to face serious times with our labor conditions. Were only the interest of the foundry at stake we might feel as if we are suffering for the good of the country. Unfortunately, however, the whole industrial system of the nation is bound to meet a crisis which will be delayed or hastened by conditions which may well give us grave concern.

From the medieval times of the "Faustrecht" we have come to recognize that *Power* must be made to go with *Responsibility*. In other words, a breach of the peace, or a breach of contract, is and can be properly punished in a normally constituted community.

We will therefore see the compulsory incorporation of organizations which aim to regulate the status of labor, and thus the "right of might" will be whipped into subjection to the highest welfare of the state. This may take some time, but it is sure to come.

This brings us to another phase of the foundry labor question, and one which is more closely identified with the actual operating, the general aspect of the labor question being rather a matter of policy and finally an added expense to the buying public. The eight-hour day has long been demanded, and I predict that it will come. Whether it will bring disaster to our industry, or will find us prepared to balance matters by suitable changes in our running methods, may well be worth our careful attention.

Production Increase

Do you note the general inquiry with reference to running the cupola continuously? You may not be aware that many foundries are already running two shifts and could easily arrange for three if a sufficient number of molders were available. The arbitrary arrangement of the apprentice question is bound to take a fall in the near future, and molders, good ones and many of them, will take work where it is offered. The solution of the whole future of the foundry lies in the molding machine and men with better all-around foundry education.

Probably nine founders out of ten will tell you that night work is not good. I have never found this to be the case, but always enjoyed the sight of floor upon floor of molds ready to pour the first thing in the morning. With plants as light at night as in the daytime, with proper organization, and short hours instead of the usual eleven hour night shifts, wonders of work can be accomplished.

Now I predict that something along these lines will come sooner or later, and if the foundry industry, which is looking very closely into the recent experiments with double turns, is sufficiently alert, the coming eight-hour day need not be feared very much.

In concluding the labor question mentioned, I cannot refrain from adding a few remarks on the industrial capacity of the country at large, and the foundry in particular. We only build immense plants. We are enlarging the old ones to an extent which really means further immense plants. We have them full today, and nearly deserted tomorrow.

Curtailed Operation

This is not political economy, and means that, when the hard times do hit us, we take work at less than cost to keep up our organizations. Many a nice, fat surplus is wiped out in the hard times. This is not right, and perhaps the three eight-hour shifts mentioned above may help to solve the difficulty in a measure, for a smaller plant will do for the normal output, a tightening up of conditions is met with cutting out one shift, and hard times with one turn, or even less, at work, where otherwise a vast establishment will run short handed three days a week.

Already we have some nine and one-half hours only of the twenty-four put in at actual production; the balance of the day sees the machinery idle, while the company's notes are piling up interest. With the eight-hour day things will be worse unless a resort is made to steps such as I have indicated. We would therefore see a plant necessarily three times as great in the layout as need be, and practically three times the capital tied up in it, two thirds of which is doing nothing, in fact, costing interest. What could not be done with this vast amount to

(Continued on Page 69)

SKIMMER SCREENS FOR

NON-FERROUS CASTINGS

E. T. Myskowski
and
H. F. Taylor

PREVENTING THE ENTRY of non-metallic material into the mold cavity with the molten metal is a problem which requires attention whenever a casting is poured. Founders of magnesium have overcome this difficulty to a large extent by placing skimmers made of perforated sheet steel in the gates of the molds. These skimmers mechanically entrap the solid non-metallic materials. Experiments were performed to determine the utility of such skimmers in brass and bronze foundry practice. Observations made from these experiments are discussed.

It was noted that a plane of weakness occurred in the metal where the perforated steel sheet was inserted. A magnesium casting, after it had been shaken from the sand, was accidentally dropped on the floor and the gate was broken evenly at the skimmer by the slight impact of the fall.

From this observation, it was deduced that these perforated steel sheets might be placed under risers so that the risers could be removed by impact rather than by sawing. Experiments made to determine the best practice for placement of screens under risers are described and the results are discussed.

Placement of the Perforated Steel Sheet in the Gate. The perforated steel sheet ("screen" or "skimmer") used in these experiments had a thickness of 0.015 in. and contained 12 openings per linear inch; the diameter of each opening was 0.032 in. This screen is typical of that used for straining magnesium (Fig. 1). Several methods by which the skimmer may be inserted in the gate are illustrated in Figs. 2 through 6.

Ingate Enlarged

In each case, it may be noted that the cross-sectional area of the ingate at the point of insertion of the screen is enlarged. This enlargement is made because the openings in the screen constitute only about 30 per cent of the total screen area. If the ingate is not enlarged at the screen, the skimmer exerts a choking action which is undesirable in many instances. Moreover, some of the holes in the screen become clogged as pouring progresses. For these reasons, the cross-sectional area of the ingate at the screen should be about six times that of the normal cross section of the ingate.

Figure 6 shows a screen placed at the junction of the ingate and the casting. A screen so placed must be heavier than the standard magnesium screen in order to resist deformation under the force of the hot metal. It has been found that a screen about 0.050 in. thick with about 10 holes per linear inch is suitable for this application. Placement of the screen next to the casting permits removal of the sprues by impact rather than by cutting.

Effectiveness of Skimmers. Figure 7 shows a sectioned ingate taken from a manganese bronze casting. The direction of metal flow during pouring was from right to left. Obviously, the screen withheld most of the dross and dirt and prevented it from entering the casting. A definite statement cannot be made regarding the quantitative efficiency of the screen for removing dross because direct measurements cannot be made.

However, it has been observed that surface cleanliness and internal soundness of castings poured through the skimmers have been definitely improved as compared with castings which were poured without skimmers. It is possible that skimmers may act to lessen the turbulence of flow and thereby prevent some dross formation in the mold.

Advantages of Placing Screens Under Risers. Removal of risers of any size is difficult and expensive. This is especially true if the riser joins the casting at an inaccessible spot and can be removed only by

Defects caused by dirt can be largely eliminated in copper-base alloy castings by the use of perforated steel sheets. Inserted in the ingate of the mold, the screen prevents dirt and dross from entering the mold cavity. Cleaning costs can be reduced by insertion of the screen in the mold cavity at the junction of risers and casting.

The views expressed herein are those of the authors, E. T. Myskowski, Steel Castings Sec., Div. of Physical Metallurgy, Naval Research Laboratory, of the Office of Research and Inventions, and H. F. Taylor, now Research Associate of M.I.T., Cambridge, Mass., and do not necessarily reflect those of the Navy Dept.

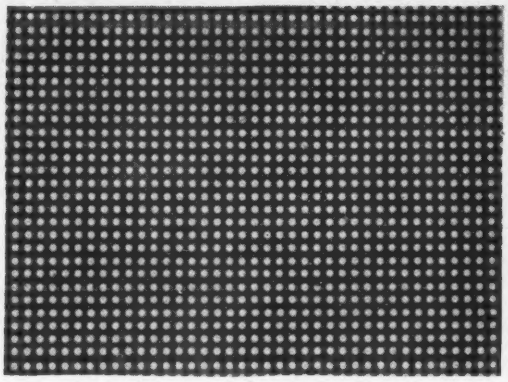


Fig. 1—Magnesium skim gate material.

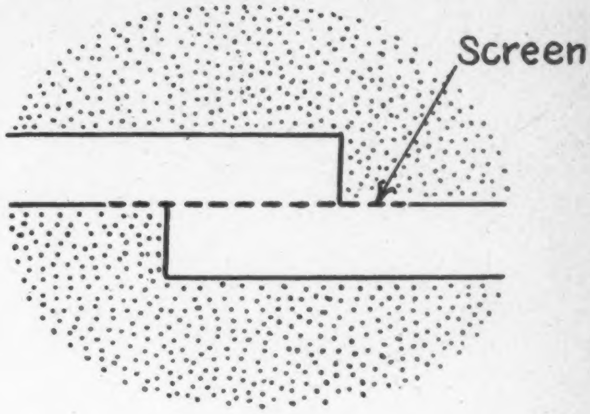


Fig. 2—Screen placed in staggered ingate.

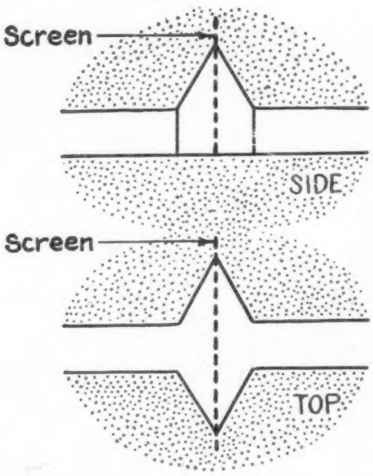


Fig. 3—Ingate enlarged for screen.

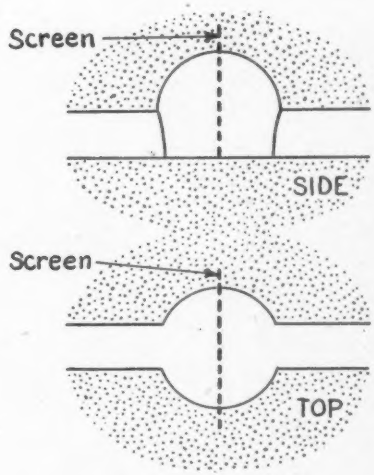


Fig. 4—Screen inserted in "blind head" in ingate.

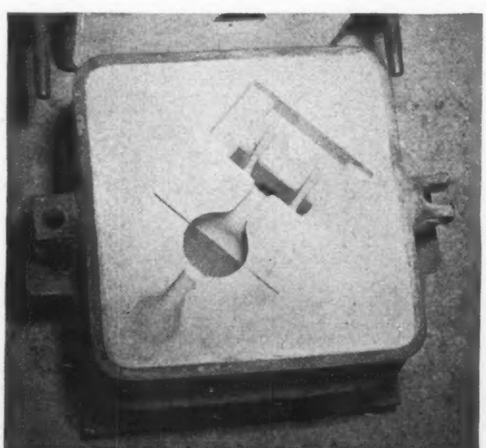


Fig. 5—Position of screen relative to casting.

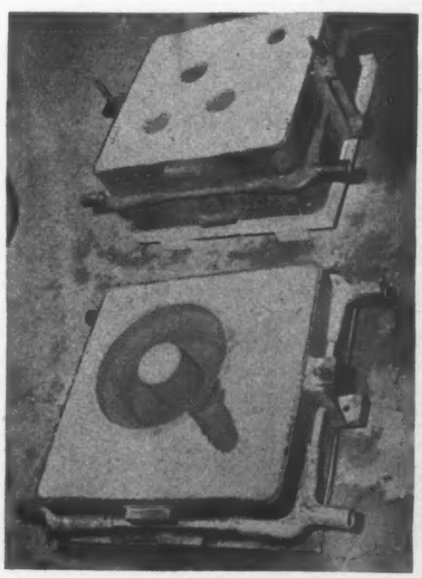


Fig. 6—Screen placed next to casting.

Fig. 7—Screen in ingate, illustrating cleaning action.

Fig. 8—Screen molded in sand under riser form.

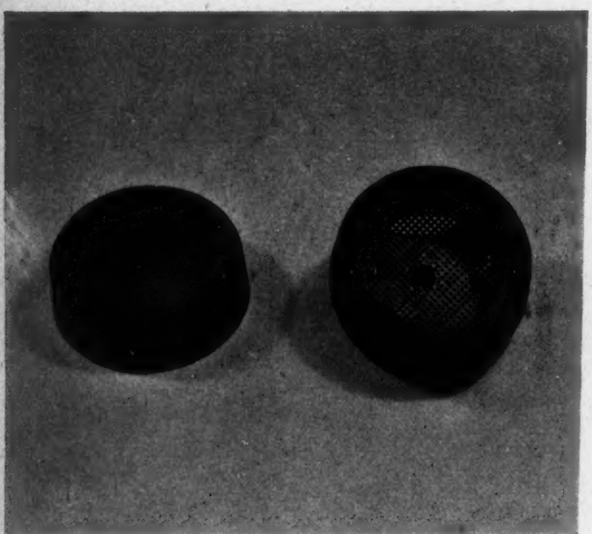


Fig. 9—Screen invested in sand core.

Fig. 10—Riser knocked off with hammer.

Fig. 11—Riser knocked off with hammer blow.

Fig. 12—Riser detached from casting.

Fig. 13—Screen pulled away from riser.

Fig. 15—Defect produced by depression of flat screen into casting.

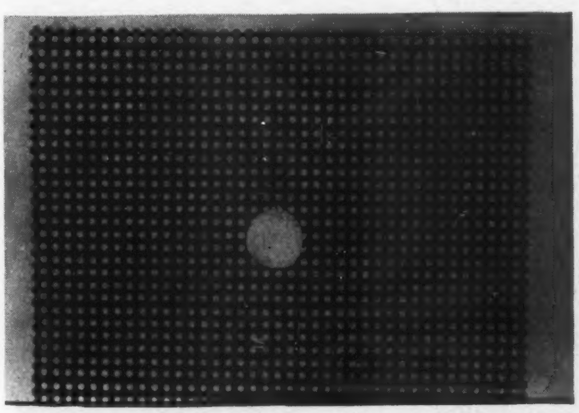


Fig. 17—Screen with center hole punched.

Fig. 14—Casting ready for finishing.

Fig. 16—Casting produced when screen is raised above casting.

Fig. 18—Dies and tube used for forming.

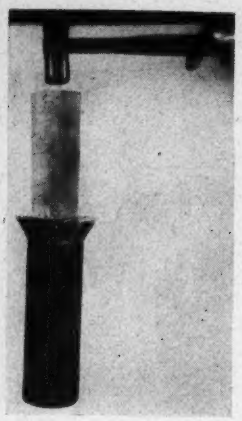


Fig. 19—Forming operation.

chipping. However, if a screen is placed at the junction of the riser and the casting to cause a plane of weakness at that point, the riser can be flogged off easily.

In practice, a screen can be molded into the sand, as shown in Fig. 8, or invested in a core sand ring, as shown in Fig. 9, which is inserted into the base of the riser cavity. Regardless of where the riser is located, cleaning costs may be reduced materially by proper use of screens. Figures 10 through 13 show a riser being knocked off with a hammer blow.

Cleaning Temperatures

After the casting has been poured, the cope is removed when the top of the riser is black. Manganese bronze and the lead-free tin bronzes are cleaned just below the "red heat" range. At this temperature the riser may be knocked off more easily than when the casting has cooled down to room temperature. With the leaded tin bronzes, the casting should be allowed to cool further and should be cleaned at temperatures below 500° F. in order to prevent damage.

Aluminum alloys can be cleaned at room temperature, since most of these alloys are sufficiently brittle in the "as-cast" condition to permit easy removal of the riser. If a casting is such that the cope cannot be removed safely, the sand around the riser may be loosened so that a cable can be hitched around the riser, which can then be lifted from the casting.

A casting ready for finishing is shown in Fig. 14. The small amount of metal remaining at the base of the riser can be removed easily by milling or in the rough machining.

Forming Screens to Prevent Deformation. Properly prepared screens will permit easy "knock-off" of manganese bronze risers with diameters of 8 in. or more. However, to prevent scrap losses resulting from improper use of the screens, certain precautions must be observed.

If a flat screen is placed at the base of the riser along the exact contour of the casting, the force of the hot metal flowing from the riser during feeding will deform the screen into the casting and produce a defect of the type shown in Fig. 15. This may be overcome by raising a flat screen above the top of the casting, as in Fig. 16. However, the excess metal which must be removed lessens the saving resulting from use of the screens.

Reinforced Screens

In order to work properly, the screen should be reinforced to withstand the deforming action of the hot feed metal. The simplest and most efficient method of reinforcing the screen is to shape it in the form of a dome. Figures 17 through 20 show the various steps in the formation of such a screen.

Radius of curvature of the dome should be approximately twice the diameter of the riser. If the radius is smaller, too much metal remains to be ground away after the riser is removed, and if the radius is greater than twice the diameter of the riser, the screen may sag and be forced into the casting. The formed screen (Fig. 20) may then be invested in a sand core or molded into the sand under a riser form.

Feeding Through Screens. It will be noted in Fig. 17 that a prepared screen has a sizeable hole in the center. This hole is punched to prevent the formation of a defect such as shown in Fig. 21. As solidification of the metal proceeds, the metal in the riser feeds through the screen, but as the temperature of the feed metal falls, the last of the molten metal becomes too sluggish to pass through the small openings in the screen. The large hole in the screen allows final feeding to occur.

It has been determined that the diameter of the hole should be about one-fourth the diameter of the riser. When the casting is so designed that it may be top-poured, the hole is not punched in the screen because it would interfere with the skimming action of the screen and is not necessary for proper feeding. In this case, the screen and adjacent sand are preheated by the passage of all of the metal going into the mold cavity so that the screen has no apparent chilling effect and the feeding through the small holes in the screen is adequate to produce a sound casting.

Iron Contamination from Screens. Founders of tin bronzes may be apprehensive about iron contamination by screens. This possibility must be taken into account as most specifications allow little, if any, iron to be present in the alloy. On the basis of tsets conducted, it has been found that castings weighing well over 100 lb. can be poured through a 1-oz. screen in the ingate, and the screen is not dissolved or attacked by tin bronzes or manganese bronze.

However, if the screen were dissolved completely in a casting of the above weight, the total iron contamination would be only 0.06 per cent. The screens may be stripped from the metal with pliers, as shown in Fig. 13, or they may be left on the gates and risers and skimmed off after the scrap charge has been

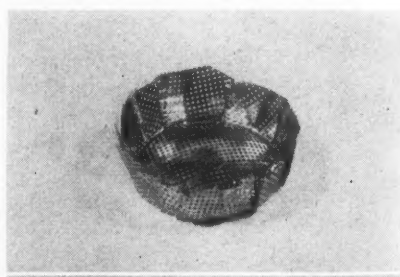


Fig. 20 (top)—Screen ready for use.
Fig. 21 (bottom)—Shrinkage resulting from absence of center hole.

melted, since they are not dissolved at temperatures normally encountered in melting or pouring manganese bronze and tin bronzes.

Oxide Coatings on Screens. Adherent oxide coatings can be formed on screens by heating the sheets for about 1 hr. at a temperature of around 1000° F. The oxide will prevent burning or erosion of the screens by metals which could cause trouble with the uncoated screens. Since the screens so treated are not wetted by the metal passing through them, removal of the screens from gates and risers is facilitated. Oxide coatings also prevent rust formation on screens during storage. Rust, if present, could cause blow-backs when it comes in contact with molten metal.

The perforated steel sheet used as a skimmer in magnesium founding can be used to advantage in casting copper-base alloys. When inserted in the ingate of a mold, the screen prevents dirt and dross from entering the mold cavity. Casting defects caused by dirt can be largely eliminated in this manner.

The same screens, properly prepared, can be inserted in the mold cavity at the junction of risers and castings. The risers may then be knocked off while the castings are hot, and thus cutting and chipping operations are avoided. Cleaning costs are considerably reduced thereby. The savings are greatest where risers join castings in places not easily reached with saws.

Contamination of copper-base castings with iron is not a problem arising from use of the screens.

GERMAN CASTING
Technology Is Reviewed and Evaluated

CENTRIFUGAL CASTING of metals was developed in Germany to a degree comparable with that in the United States and rather beyond that in Great Britain, according to report of J. T. MacKenzie, American Cast Iron Pipe Co., Birmingham, Ala., who visited the conquered nation and inspected production facilities as a member of a government technical mission.

Mr. MacKenzie, who serves as an A.F.A. representative on the U. S. Ordnance Committee and is active on numerous other A.F.A. national groups, found that methods and machines for production of cast iron pipe—largest tonnage item of the field—were those in common use before the war. In fact, large new production facilities (Buderusche Eisenwerke, Wetzlar) were shut down early in the war, since they were not needed.

One significant development—which, Mr. MacKenzie observes, may prove to be an important contribution to the science of centrifugal casting—was noted: the use of thin silica sand lining on the mold face in the horizontal casting of gun barrels, high chrome steel tubing and steel cylinder liners. Application of the sand lining was developed by Dr. Poelzguter, and the technique was in use in several plants.

Casting of steel gun barrels was highly developed, the report states. Clean, round grain silica sand, of approximately 30-70 mesh, is used to line the mold face to a depth of approximately 5 mm. Too thin a lining, e.g. 3 mm., is said to result in longitudinal cracks in the casting; while too thick a lining, e.g. 7 mm., results in a tendency of the lining to wash, resulting in swells in the metal.

Method of placing lining consists in dumping sand from a trough, equal in length to the mold, after the mold has reached full speed. Mold used is of chrome steel, 1½-in. thick; and runs in a tank of water, being driven through a gear train. Machine tilts to an angle of 12-15° during pouring of metal.

Some penetration of the sand by the molten steel takes place, which penetration, however, does not seem to result in lifting of the sand. Sand comes off the casting readily during subsequent heat treatment.

Steel Tubing

Horizontal spinning of high chrome steel tubing, with wall thickness of 1 to 2 in., was also accomplished through the thin sand lined mold. In this case, only 2-mm. thickness of silica sand was used on the mold face. Mr. MacKenzie reports that the surface of the tubing appeared highly satisfactory, and with no apparent penetration of the sand.

In the manufacture of cast iron automotive cylinder liners, the Germans used methods and equipment common in England. For steel liners, however, machines developed in Germany were almost identical with the latest types in the United States, incorporating the advantages of simple cylindrical shape of the mold—to ease thermal stresses—and removal of the mold after each cast, to allow better control of mold temperature and dressing of mold face.

Vertical spinning in was found to be apparently on a par with similar production in the United States, with the principles of directional solidification carefully observed.

Features of considerable interest in the casting of brass and bronze are the use of thin copper sheet as lining in cast iron molds, and a coke oven gas atmosphere in the mold. The copper sheet is cut to exact size (allowing for expansion under heating by hot gas flames before pouring) and slipped into the mold immediately before casting. Mold is filled with the coke oven gas before pouring, and gas atmosphere is maintained until solidification has been completed. Combination is designed to eliminate pin holes and add to life of the mold.

Northern California Issues Booklet on Sand

SAND CONTROL is the subject of the annual report of Northern California A.F.A. chapter's foundry sand and mold materials committee, which has issued the report as a 32-page printed booklet dedicated to, and entitled, "The Man at the Muller."

Pointing out that the sand mill operator has one of the most important jobs in the foundry and expressing opinion of the committee that he has been "somewhat neglected in our technical literature," the booklet urges more careful instruction and explanation by foremen. First section of the text contains detailed suggestions for foreman's instructions to a new employee assigned to the muller.

Following portions of the work contain a comprehensive discussion of mulling, its advantages and effect on various types of sand; general requirements of foundry sands; and controlling properties of the sand.

CAST ALUMINUM ALLOYS

HEAT TREATMENT

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and
W. E. Sicha
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EFFECTS OF HEAT TREATING aluminum alloys can be followed more readily after examination of the sequence of events occurring during the solidification process. An aid in studying the course of solidification is provided by constitutional diagrams such as have been established for the commercially important aluminum alloy systems[1,2].

These constitutional diagrams are constructed from data obtained by observing the melting and freezing characteristics and the microstructures of a series of alloys in which the relative concentrations of two or more metals are varied. The following discussion of solidification will be based on the partial constitutional diagram of a hypothetical two-component system shown in Fig. 1.

An alloy of the composition indicated by the line *R-S* is completely liquid at the temperature represented by *R*. Solidification starts at a temperature corresponding to point *T*. The first material to solidify does not have the composition of the hypothetical alloy but has a concentration of element *B* indicated by the point *U*. In other words, the first material to solidify contains a far lower concentration of alloying element than is represented by the average composition of the alloy.

Presented at an Aluminum and Magnesium Session of the Fiftieth Annual Meeting, American Foundrymen's Association, at Cleveland, May 7, 1946.

However, as solidification proceeds, the material solidifying increases in concentration of element *B* along line *C-D*. Since this material continues to contain less than the average content of element *B* in the alloy, the concentration of element *B* continues to increase in the liquid along the line *C-E*. For example, at temperature *W* the composition of the material that solidifies is represented by *X*, and the remaining liquid, which has been enriched with element *B*, is of the composition indicated by *Y*. At the temperature *V*, the remainder of the liquid solidifies, and this material has an average composition designated by *E*.

This last material to solidify, known as eutectic, consists of two constituents of the compositions indicated by *D* and *F*. The temperature at which solidification is completed is referred to as the eutectic temperature, and the temperature interval *T-V* is the solidification range of the alloy.

Factors involved in the successful heat treatment of aluminum alloy castings have become of more general interest as a result of the extensive increase in use and production. A thorough understanding of the commercial applications of heat treatments for aluminum alloy castings requires a knowledge of the process fundamentals. It is the purpose of this paper to review these fundamentals and to consider the structural and property changes produced in aluminum alloys by commercial heat treatments.

The resultant solidified metal is made up of two fundamental types of materials. One type forms the continuous background or matrix. This is the material that solidifies throughout the temperature range *T-V*. As solidification progresses in this range, successive layers of freezing material build up on and around the crystals that froze initially.

Dendritic Structure

This freezing material assumes a definite form, similar in appearance to a pine tree. The treelike pattern, known as dendritic structure, is illustrated in Fig. 2. It is evident from the manner in which the dendrite arms form that the concentration of *B* metal is progressively greater from the core to the outer layer. This constituent of varying composition is called a solid solution.

At final solidification, occurring at the temperature indicated by the line *D-E*, the eutectic freezes between and around the dendrite branches. As previously mentioned, the eutectic is made up of intimately mixed solid solution of composition *D* and intermetallic compound of the composition given by the line *G-H*. The latter constituent is called an intermetallic compound largely because of its relatively unvarying composition, and is the other phase or fundamental type of material in the solidified metal.

The properties of both the solid solution and intermetallic compound phases of the solidified metal differ from those of pure *A* metal. Within the solubility limits of *B* in *A*, increasing concentrations of *B* gener-

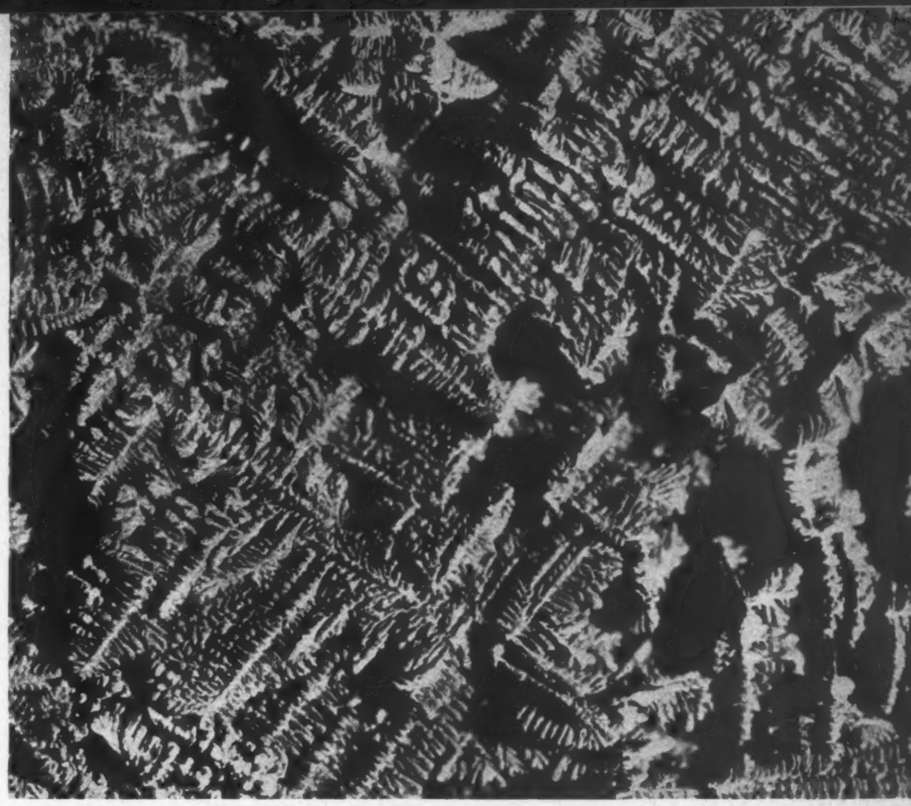


Fig. 2—Dendritic structure developed during metal solidification.

ally produce an alloy of gradually increasing tensile strength and decreasing ductility. Intermetallic compounds usually are hard and brittle. These phases naturally impart their characteristics to the alloy to a degree dependent upon the concentrations present.

Variations in concentration in the solid solution tend to be reduced by diffusion during the solidification process. Also, diffusion is the mechanism by which changes in structure occur as a result of the reduced solid solubility of *B* in *A* with decreased temperature. However, time is an important factor in the process of diffusion, and a rapid rate of solidification will retain concentration gradients which are not in equilibrium at the lower temperatures.

The solid lines in Fig. 1 represent the structures which should prevail under equilibrium conditions or after slow cooling to any specific temperature. With cooling rates such as ordinarily prevail in production of commercial castings, equilibrium is not attained and structural conditions may be more nearly as represented by the dotted lines in Fig. 1. Undercooling, resulting from rapid cooling, tends to lower the temperatures of initial and final solidification. The faster cooling rate results in the formation of relatively smaller volumes of solid solution constituent and larger volumes of intermetallic compound than would occur under equilibrium conditions. This effect is illustrated by the shift of maximum solid solubility from position *D* to *D'*.

Rapid cooling also tends to preserve supersaturated solid solutions and, as is indicated by the relative positions of *I* and *I'*, to retain a larger amount of solid solution. Another point of difference in commercial casting alloys is their normal impurity content. Presence of these impurities introduces one or more additional constituents that have the effect of impeding the normal tendency for adjustment toward equilibrium during solidification.

Heat Treatment. The fact that the solubility of certain elements in aluminum varies with temperature, in the manner indicated by the line *D-I* in Fig. 1, is the basis for heat treatment. The objective of heat treatment is the controlled alteration of properties. Relationship with the foregoing discussion of the solidification process will be evident as the various types of commercial heat treatments are considered.

Types of Heat Treatment

Heat treatments applied to aluminum alloy castings can be classified under the following general types:

1. Annealing treatment (intermediate temperature).

2. Solution treatment (high temperature).

3. Artificial aging treatment only (low and intermediate temperatures).

4. Solution treatment followed by low temperature artificial aging treatment.

5. Solution treatment followed by intermediate temperature artificial aging treatment (overaged).

Data on the mechanical properties and uses of heat treated aluminum

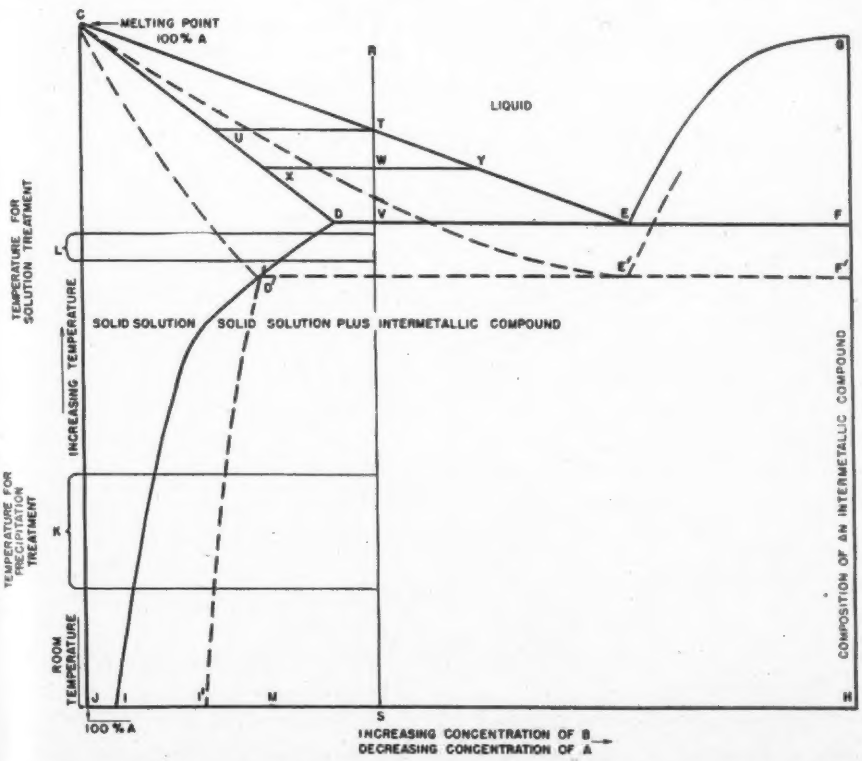


Fig. 1—Partial constitutional diagram of a hypothetical two-component system—course of solidification.

casting alloys are generally available[2,3,4,5,6]. Examples of some of the more generally used commercial heat treatments are given in Table 1.

Casting Requirements. Castings must be of the specified chemical composition and of good quality in order to obtain the expected response to heat treatment. This fact is generally appreciated but it can not be emphasized too strongly. Factors contributing to the production of sound and fine grained aluminum alloy castings are treated in other publications[1,4,6].

Furnaces for Heat Treatment. Air-chamber furnaces of proper design are best suited to heat treatment of aluminum alloy castings. Furnaces may be heated by electric heating units, radiant tubes, or, if harmful products of combustion do not enter the heating chamber, by gas or oil burners. Gas furnaces in which the products of combustion are circulated, when suitably designed, can be used satisfactorily in many cases provided that the atmospheres contain a sufficiently high percentage of carbon dioxide and are free of sulphur compounds and excessive moisture[7].

Furnace design should provide a uniform temperature within $\mp$ 5° F. throughout the working zone. Mechanical circulation of the air is essential to accomplish this result and to decrease the heating cycle. Baffles generally are necessary to prevent air being circulated directly from the heating units onto the metal. For electrical resistance heating, units with a low energy imput per unit of area are desirable.

Temperature Control. Furnaces should be equipped with recording pyrometers and automatic temperature control instruments to insure the necessary degree of control. Automatic limit controls which can be set at a temperature slightly higher than the operating temperature are also desirable to provide insurance against damage from accidental overheating through failure of the control equipment. All pyrometric equipment including the thermocouples should be frequently checked against standards.

Furnaces should be surveyed before putting them into service to make certain that the temperatures throughout the working zone are within the prescribed limits of $\pm$ 5° F. This entails checking the temperatures through the heating cycle with several thermocouples placed in different locations in a typical charge of castings.

Annealing Treatment. Castings frequently are annealed for the purpose of relieving the internal stresses that may be induced by contraction during cooling around more or less resistant cores, or by the differential cooling rates of sections of varying thickness. Annealing is also employed to bring about precipitation of alloying constituents from solid solution in which they may have been retained by a relatively rapid rate of cooling in production.

Thus, annealed castings have a structure that is practically insensitive to change at the temperatures ordinarily encountered in elevated temperature operation. They are not subject, therefore, to permanent dimensional changes in service.

Microstructure Changes

Changes in the microstructure resulting from annealing may be visible but usually are not extensive. The microstructures of commercial aluminum casting alloys shown in Figs. 3, 7, 11, 15 and 19 are all representative of annealed material, although most of them are of "as-cast" materials.

The mechanical properties produced by annealing usually are similar to those of the "as-cast" material, although in some alloys tensile strengths slightly lower and elongations slightly higher than the "as-cast" properties result. As would be expected, this type of treatment has limited commercial application.

Solution Treatment. Referring again to the equilibrium diagram of Fig. 1, it will be noted that the line *D-I* indicates the limits of solid solubility of *B* in *A* at different temperatures. The solid solubility increases as the temperature increases, and this change is most marked in the range just below the eutectic melting temperature indicated by line *D-E*. Alloys having such solid solubility-temperature characteristics are susceptible to solution heat treatment.

Aluminum-copper and aluminum-magnesium systems, which are of this type, constitute the basis for commercially important casting alloys. Magnesium and silicon form an intermetallic compound which has solubility characteristics similar to those of copper and magnesium.

Table 1

HEAT TREATMENTS FOR SEVERAL ALUMINUM CASTING ALLOYS

	Solution Heat Treatment			Aging Treatment	
Alloy and Heat Treatment[1]	*Time, hr.*[2]	*Temperature, ° F.*[3]	*Quench*	*Time, hr.*[4]	*Temperature, ° F.*[3]
SAND CAST					
122-T61	12	950	Water at 150 to 212° F.	10-14	310
142-T21	—	—	—	2-4	650
142-T77	6	970	Still Air	1-3	650
195-T4	12	960		—	—
195-T6	12	960		3-5	310
195-T62	12	960	Water at 150 to 212° F.	12-16	310
355-T6	12	980		3-5	310
355-T61	12	980		8-10	310
356-T6	12	1000		2-5	310
PERMANENT MOLD					
122-T65	8	950		7-9	340
A132-T65	8	960		12-16	340
142-T61	4	960		3-5	400
B195-T4	8	950	Water at 150 to 212° F.	—	—
B195-T6	8	950		5-7	310
355-T6	8	980		3-5	310
355-T62	8	980		14-18	340
356-T6	8	1000		3-5	310

[1]Aluminum Company of America alloy and heat treatment designation.

[2]Soaking time periods required for average castings after load has reached specified temperature. Time can be decreased or may have to be increased, depending upon particular castings, as demonstrated by experience.

[3]Temperature setting for control instrument. Variation of temperature in furnace should not exceed $\pm$ 5° F.

[4]Exact time required influenced by foundry variables and should be selected on basis of obtaining desired typical hardness values.

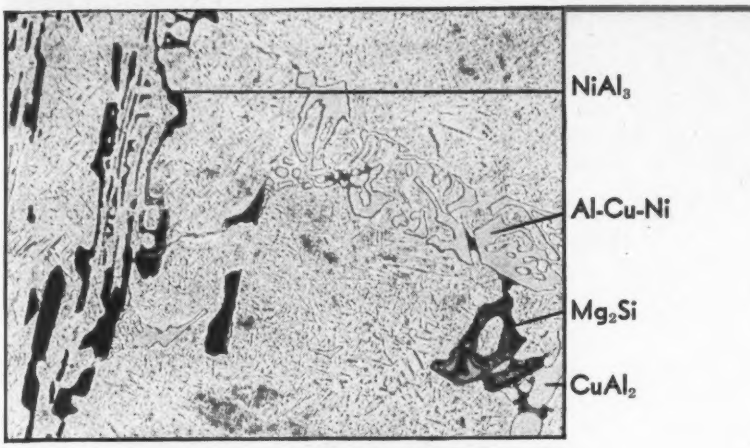


Fig. 3 — Annealed condition. The fine, generally distributed dark material in the matrix is $CuAl_2$ and Mg_2Si precipitate. In the "as-cast" condition, a much smaller quantity of precipitate is present, but in other respects the microstructure is identical with that shown.

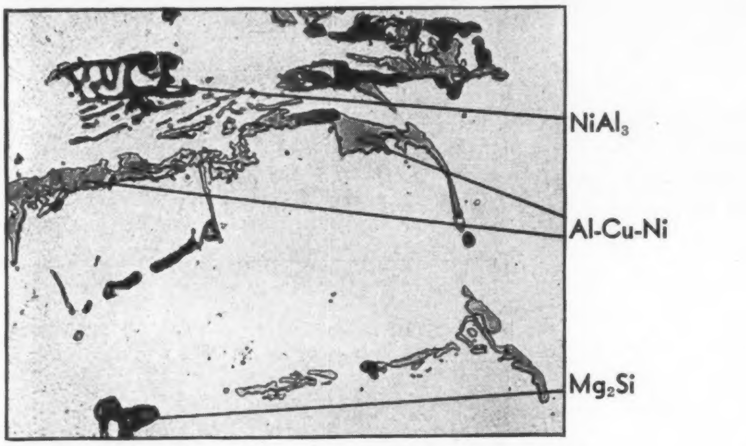


Fig. 4—Normal solution heat treated condition. Solution treatment has dissolved all the $CuAl_2$ and some of the Mg_2Si. The remaining Mg_2Si also has been spheroidized.

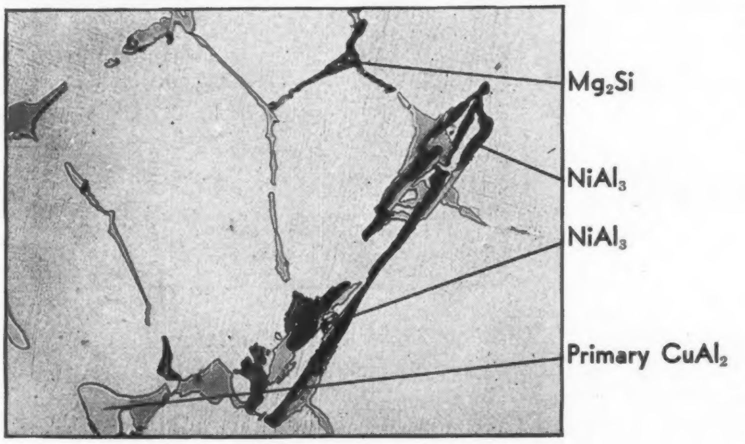


Fig. 5 — Insufficient solution heat treated condition. Some $CuAl_2$ remains undissolved and the Mg_2Si still is angular, indicating incomplete heat treatment.

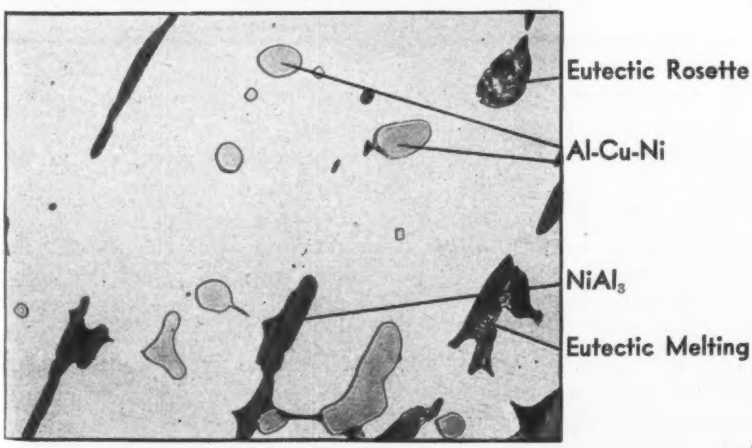


Fig. 6 — Overheated or "burned" condition. Evidence of overheating is shown by eutectic deposits and also agglomeration and spheroidization of the insoluble constituents.

0.5 per cent HF etch **500X**

Representative Photomicrographs of No. 142 Aluminum Alloy.

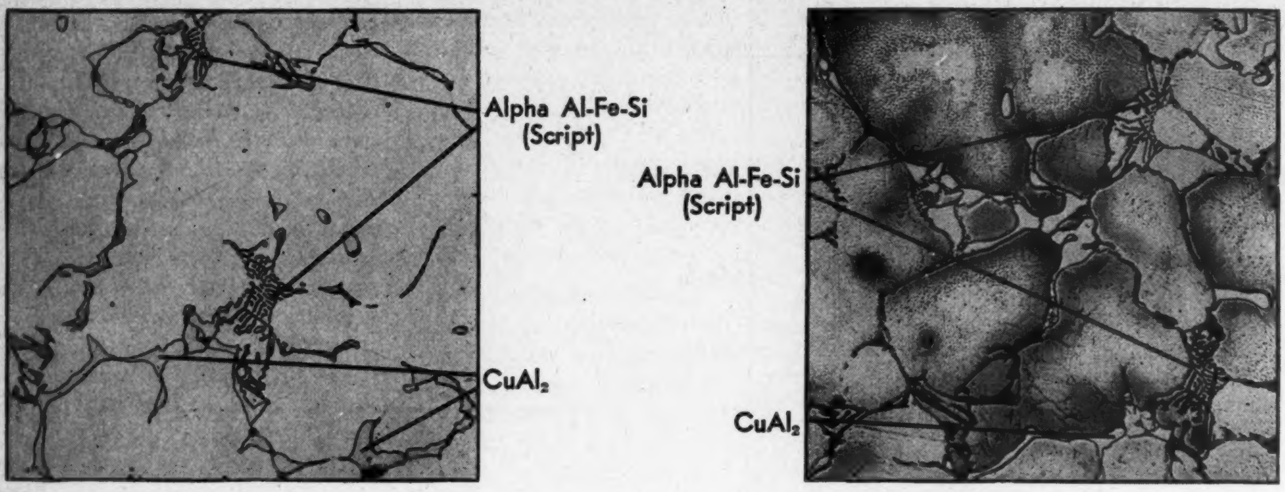


Fig. 7—Representative photomicrographs of No. 195 aluminum alloy. "As-cast" condition. These specimens show a large amount of $CuAl_2$ which is typical of the "as-cast" condition. Note cored structure revealed by mixed acid etch. Left—0.5 per cent HF etch. Right—2.5 per cent HNO_3, 1.5 per cent HCl, 1.0 per cent HF etch. 250X.

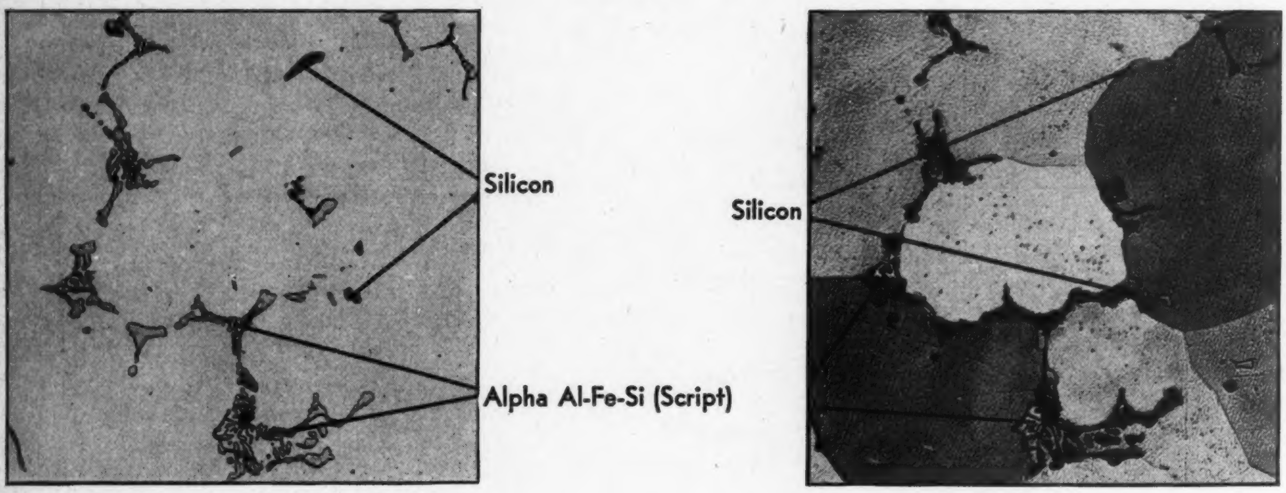


Fig. 8—Representative photomicrographs of No. 195 aluminum alloy. Normal solution heat treated condition. Note that the $CuAl_2$ has been completely dissolved. Also note absence of the cored structure which appears in the "as-cast" condition. Left—0.5 per cent HF etch. Right—2.5 per cent HNO_3, 1.5 per cent HCl, 1.0 per cent HF etch. 250X.

This compound, known as Mg_2Si, forms a pseudobinary system with aluminum, and casting alloys of this system are heat treated commercially. A noteworthy point regarding the compositions of these commercial alloys is that the concentration of soluble element *B* generally is lower than the concentration designated by *D* in Fig. 1, and usually is of the order of composition indicated by *M*, Fig. 1.

In general, the solution treatment temperature for an alloy is limited by the solid solubility line and the eutectic or solidus temperature, and generally falls in the range indicated by *L* in Fig. 1. Since the rate of atomic diffusion of the soluble constituent increases rapidly with increasing temperature, use of the highest safe temperature is desirable.

The maximum temperature is limited by the eutectic melting temperature, and may be governed also by the strength of the alloy at that elevated temperature. Castings should be capable of retaining their shapes, with little or no support, during solution heat treatment. This limitation may necessitate use of a heat treating temperature little above the solid solubility temperature.

Relatively long heating periods are required for solution of the soluble constituents in castings, even with the increased diffusion rate at the heat treating temperature. The time at temperature for attainment of homogeneity is less the shorter the distances through which diffusion must take place. Consequently, solution is more rapid in castings with a small macro grain size and fine dendritic structure. Hence permanent mold castings can be treated in a shorter time than sand castings.

The rate of cooling from the solution heat treating temperature must be rapid in order to preserve at room temperature the solid solution that

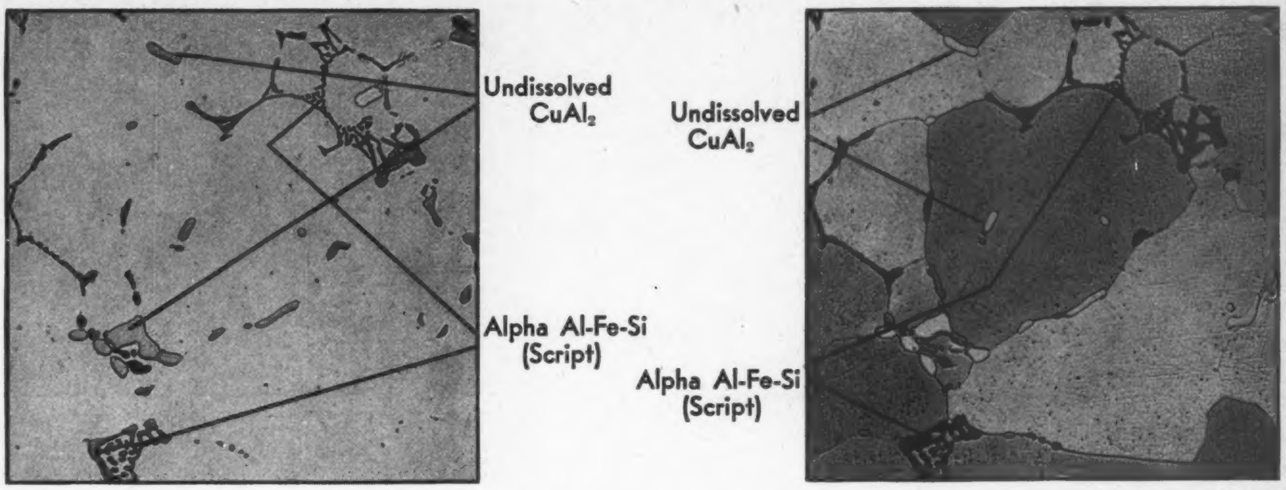


Fig. 9—Photomicrographs of No. 195 aluminum alloy. Insufficient solution heat treated condition. Note large amount of $CuAl_2$ still undissolved. Left—0.5 per cent HF etch. Right—2.5 per cent HNO_3, 1.5 per cent HCl, 1.0 per cent HF (Keller's) etch. 250X.

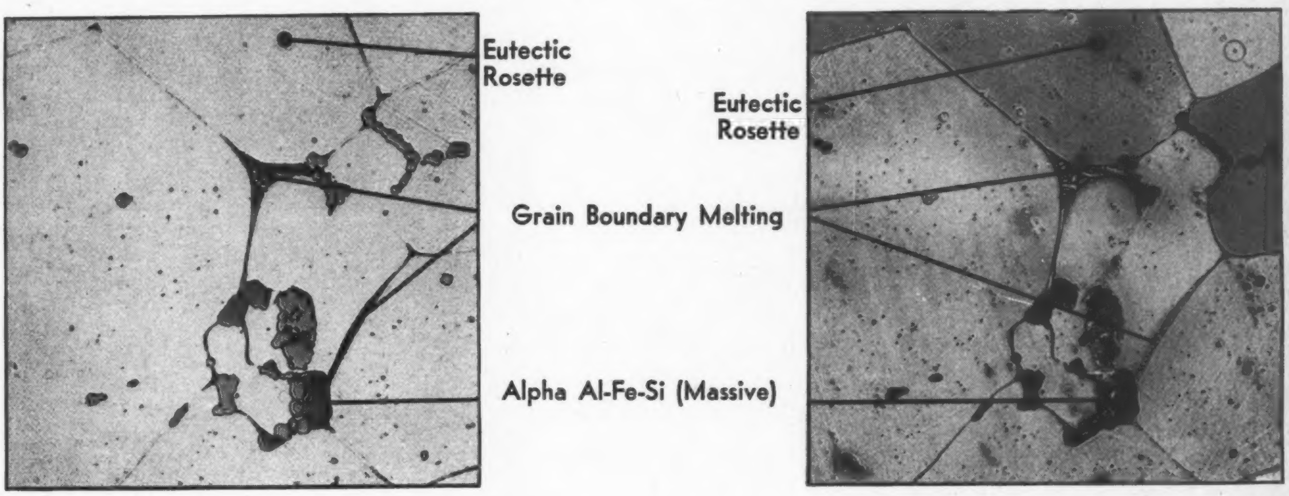


Fig. 10—Photomicrographs of No. 195 aluminum alloy. Overheated or "burned" condition. Overheating is indicated by grain boundary melting of the eutectic material and by presence of the eutectic rosette. The massive Al-Fe-Si constituent may be formed by agglomeration of the script as a result of overheating. Left—0.5 per cent HF etch. Right—2.5 per cent HNO_3, 1.5 per cent HCl, 1 per cent HF etch. 250X.

was in equilibrium at the heat treating temperature. However, an excessively rapid quench can cause extensive distortion through the setting up of excessive internal stresses. Commercial quenching practice is based upon maintaining the solid solution and minimizing the latter conditions.

Solution treatment materially increases the mechanical properties. Some of the physical properties such as density, and thermal and electrical conductivities also are altered by solution heat treatment, but to a degree that is generally unimportant except in special casting applications.

The microstructures of some solution heat treated commercial casting alloys are shown in Figs. 4, 8, 12, 16 and 20. As an aid to the metallographer, Figs. 5, 6, 9, 10, 13, 14, 17, 18, 21 and 22 provide photomicrographs illustrating improper solution treatment.

Precipitation Hardening. A supersaturated structure, such as is produced by solution treatment, tends to adjust to equilibrium conditions. Alloy constituent or compound is precipitated from the solid solution in the course of this adjustment. The rate of precipitation is a function of temperature since diffusion is essential to the progress of precipitation.

Precipitation in a solution treated alloy can be restrained almost indefinitely by keeping the material in liquid air. At such low temperatures, the atomic mobility is too low to permit the diffusion necessary for precipitate formation. The rate of precipitation at room temperature is relatively slow in most commercial aluminum casting alloys, but the rate varies with alloy composition. With increasing temperature, precipitation is progressively accelerated. An indication of the temperature range in which precipitation treatments are performed is shown at *K* in Fig. 1.

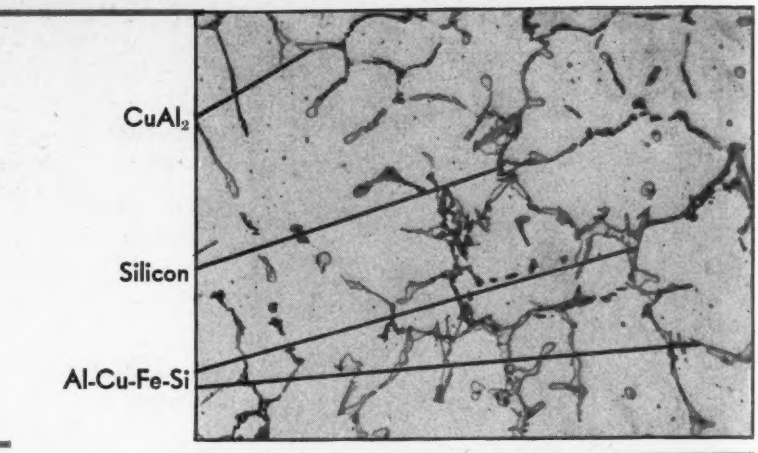


Fig. 11—"As-cast" condition. Three constituents are readily visible—rounded white $CuAl_2$, angular blue-gray silicon, and needlelike tan Al-Cu-Fe-Si. All form a eutectic concentrated along the dendrite arms and along the grain boundaries.

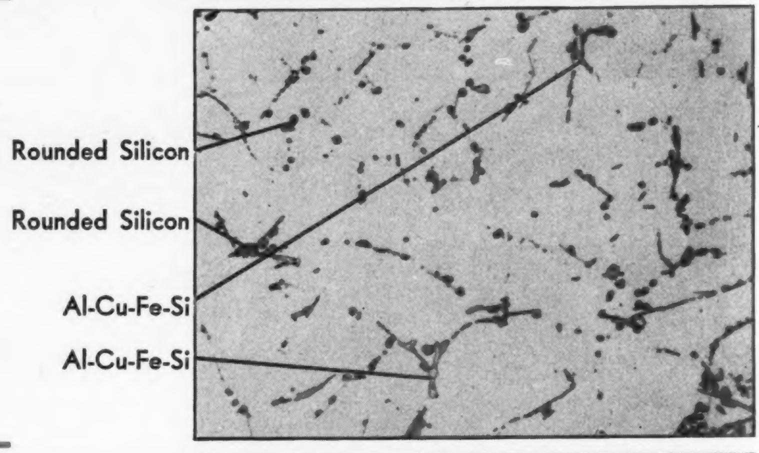


Fig. 12—Normal solution heat treated condition. Solution heat treatment has dissolved most of the $CuAl_2$, rounded and agglomerated the silicon particles and has not changed the Al-Cu-Fe-Si.

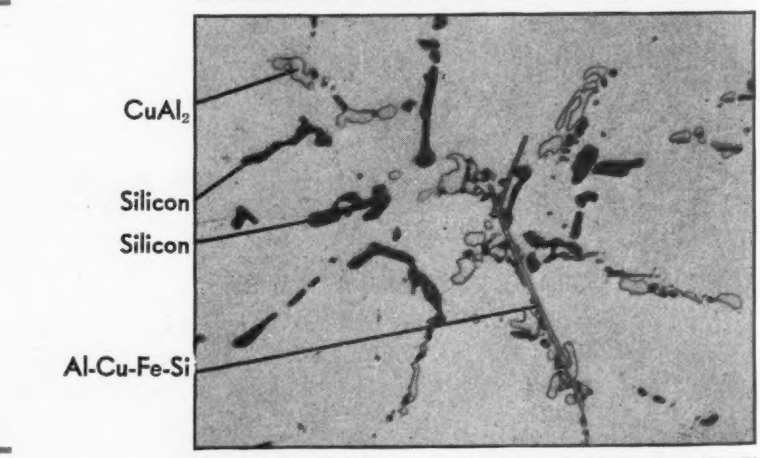


Fig. 13—Insufficient solution heat treatment. Solution heat treatment has not been carried on long enough or at a sufficiently high temperature to dissolve enough of the $CuAl_2$ and agglomerate the silicon.

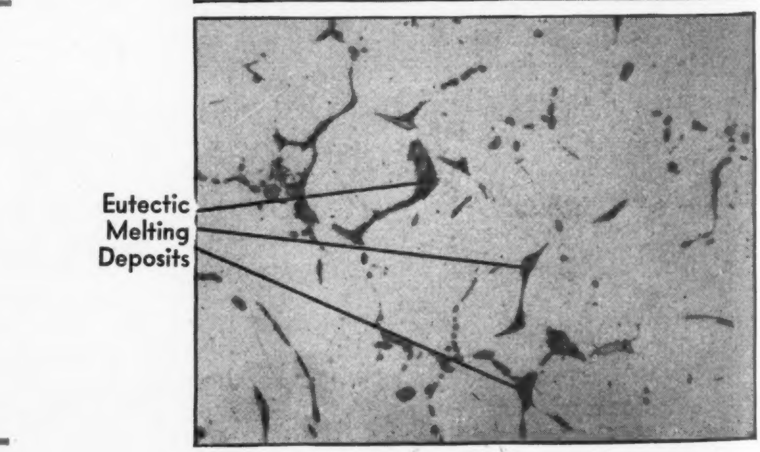


Fig. 14—Overheated solution heat treatment. Temperature has exceeded the eutectic melting point. Angular deposits are unresolved eutectic which at one time during heat treatment had been molten.

0.5 per cent HF etch **500X**

Representative Photomicrographs of B195 Aluminum Alloy.

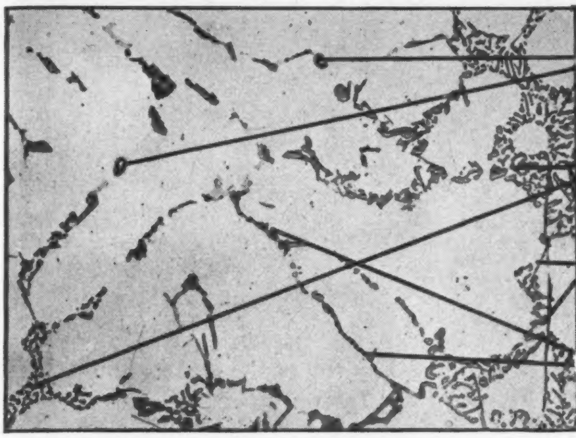


Fig. 15—"As-cast" condition. The chief constituent of this alloy is the aluminum-silicon eutectic. The precipitation hardening agents are $CuAl_2$ and Mg_2Si.

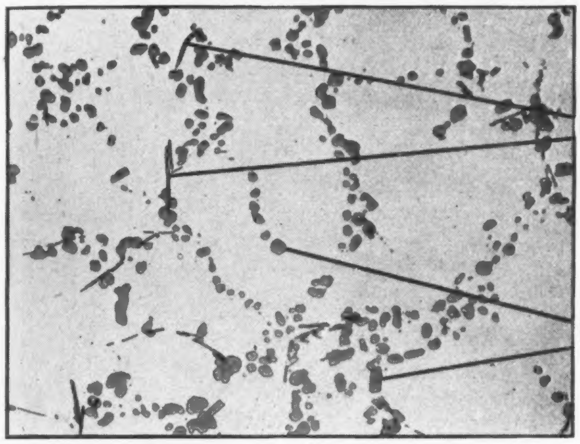


Fig. 16—Normal solution heat treated condition. The silicon particles have become rounded and have agglomerated to a certain extent due to heat treatment. The $CuAl_2$ and Mg_2Si have gone into solution but the beta Al-Fe-Si constituent is unaffected.

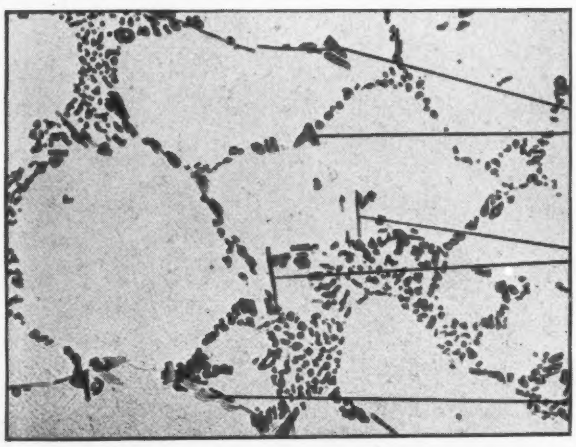


Fig. 17—Insufficient solution heat treated condition. The solution heat treatment has not been conducted at a high enough temperature or for a sufficiently long time to dissolve all the $CuAl_2$ and round the silicon particles as in Fig. 16.

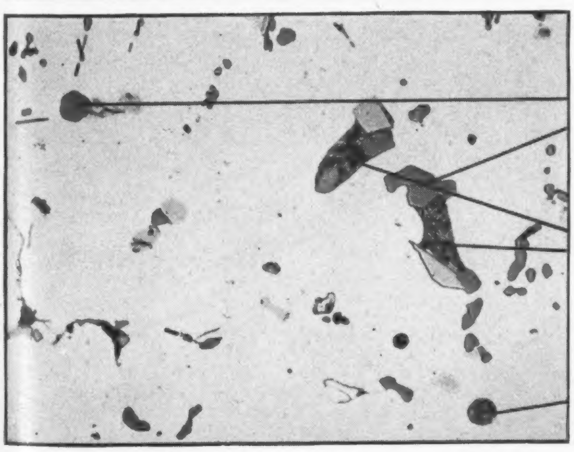


Fig. 18—Overheated or "burned" condition. Heat treatment has been carried out at too high a temperature. Some material has actually melted or "burned" as shown by the irregular and round (rosette) deposits of eutectic material. The silicon particles have markedly coarsened, which is another sign of overheating.

0.5 per cent HF etch 250X

Representative Photomicrographs of No. 355 Aluminum Alloy.

Fig. 19—"As-cast" condition. The fine aluminum-silicon eutectic is the major constituent of this alloy. Note that the silicon particles in the eutectic appear to be long and narrow for the most part. Any iron present combines with the silicon to form beta Al-Fe-Si.

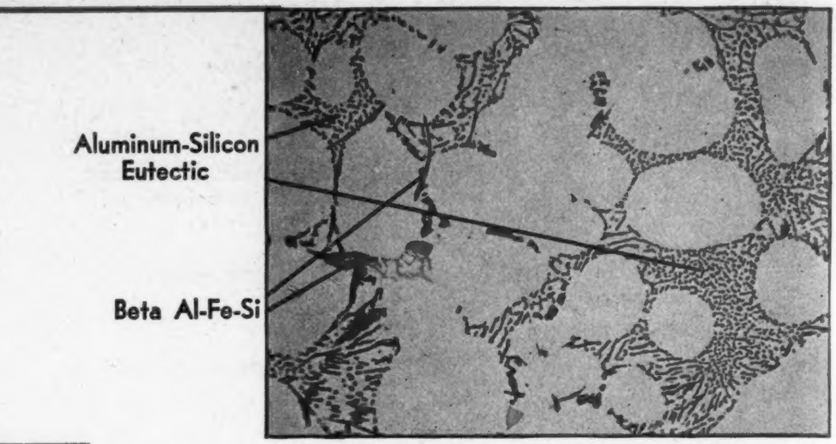


Fig. 20—Normal solution heat treated condition. Solution heat treatment has rounded and agglomerated the silicon eutectic particles but has not affected the beta Al-Fe-Si constituent.

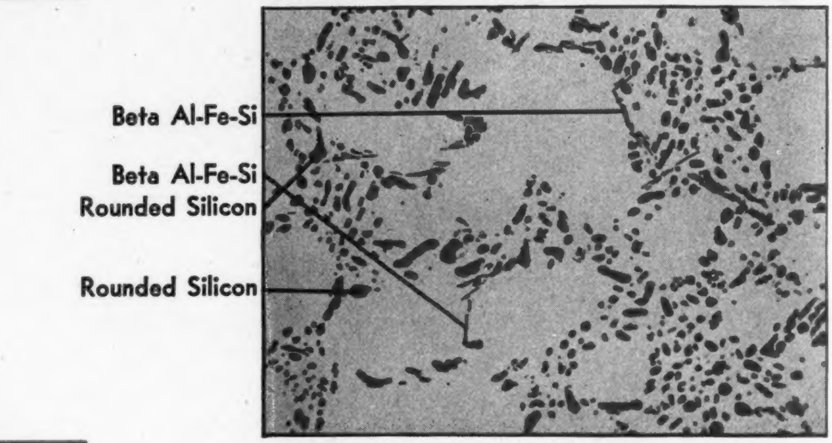


Fig. 21—Insufficient solution heat treated condition. Heat treatment has not been carried on long enough or at a sufficiently high temperature, as is indicated by the presence of some silicon particles which have remained long, narrow and angular.

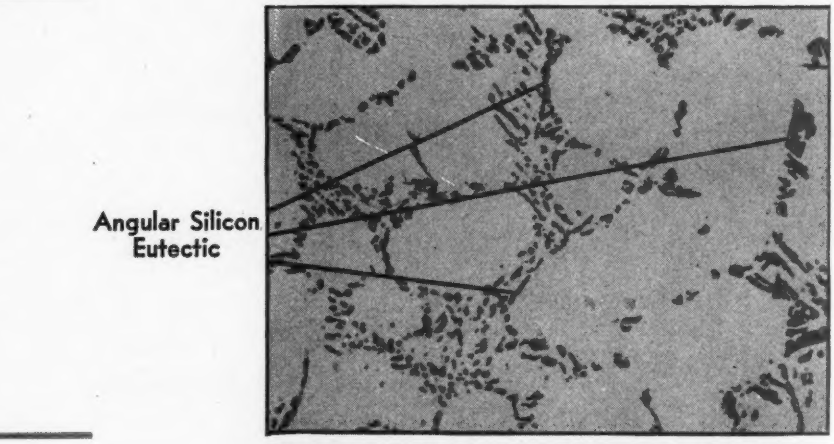
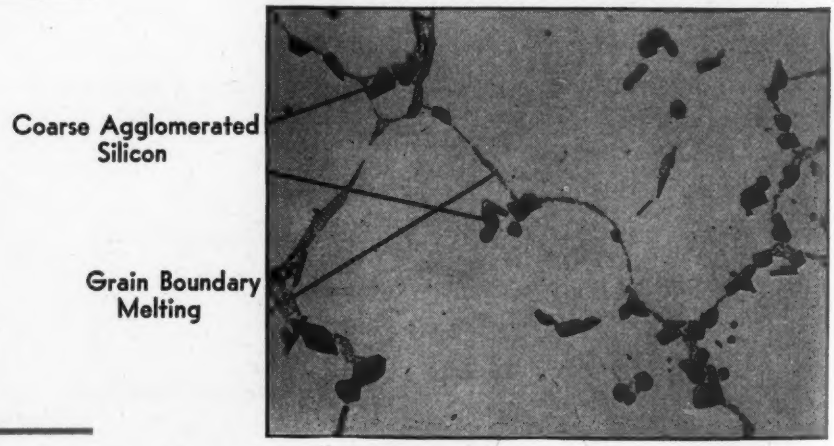


Fig. 22—Overheated or "burned" condition. Heat treatment has been carried out at too high a temperature. Actual melting or "burning" has occurred, as is shown by the heavy eutectic deposits along the grain boundaries. Note how the silicon particles have enlarged—another sign of overheating.



0.5 per cent HF etch **250X**

Representative Photomicrographs of No. 356 Aluminum Alloy.

The structural changes involved in precipitation alter the mechanical and some of the physical properties of the alloy. A typical course of precipitation at a specific temperature involves a relatively rapid increase in hardness to a maximum, followed by a decrease at a moderate rate, and then further decrease at a progressively reducing rate for an extended period of time. In general, the tensile and yield strengths vary directly and the elongation inversely with hardness. The effect of such precipitation on certain physical properties will be discussed later.

Composition and Hardness

Maximum hardness is obtained by heating for long periods of time at slightly elevated temperatures. The specific time and temperature necessary for maximum hardness usually vary with alloy composition. At higher precipitation temperatures, the heating time required to attain "peak" hardness decreases with increases in temperature. However, "peak" hardness values become progressively lower as the precipitation treatment temperature is increased.

In the initial stage, the precipitate formed is too fine for resolution under a microscope. Its presence is inferred from indirect evidence such as change in mechanical properties and etching characteristics. The particles coalesce as the time or temperature is increased, a comparatively small increase in temperature being much more effective than a large increase in time. A treatment that has coalesced the precipitate into particles large enough to be visible under the microscope usually has carried the material beyond "peak" hardness.

Artificial Aging Treatments. In production terminology, precipitation hardening treatments are known as aging treatments, and are further referred to as room temperature aging or artificial aging, depending upon whether they are carried out at room temperature or elevated temperature. Reference was made previously to the three types of artificial aging treatments for aluminum casting alloys that are of commercial importance.

Artificial aging only may be applied to castings in the "as-cast" condition. These treatments are effective because, as previously mentioned, most castings cool rapidly enough in production to retain a considerable degree of supersaturation of solid solution at room temperature. Low temperature artificial aging treatments of this type increase the tensile and yield strengths and the hardness, with some sacrifice in elongation. These changes in mechanical properties afford an improvement in machining characteristics.

Intermediate Temperatures

Aging treatments at intermediate temperatures also may be applied to "as-cast" castings that are to be operated at elevated temperatures and in which even small permanent dimensional changes would be objectionable. Density changes usually accompany structure alterations involved in precipitation. The magnitude of these density or dimensional changes, which varies with alloy composition, is not great but must be taken into consideration in some casting applications. Use of such aging treatments causes growth to occur in the castings and, consequently, prevents permanent dimensional change later during operation at elevated temperatures.

A second type of aging treatment is the low temperature treatment used after a solution heat treatment. In some cases, the aging portion of these treatments is designed to produce maximum hardness and the

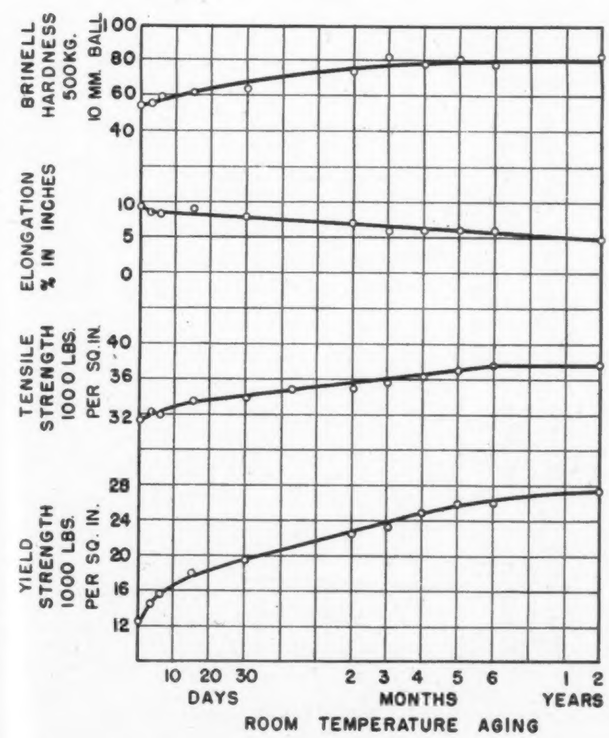


Fig. 23—Effect of room temperature aging on the mechanical properties of solution heat treated sand cast No. 195 aluminum alloy standard ½-in. diameter test specimens.

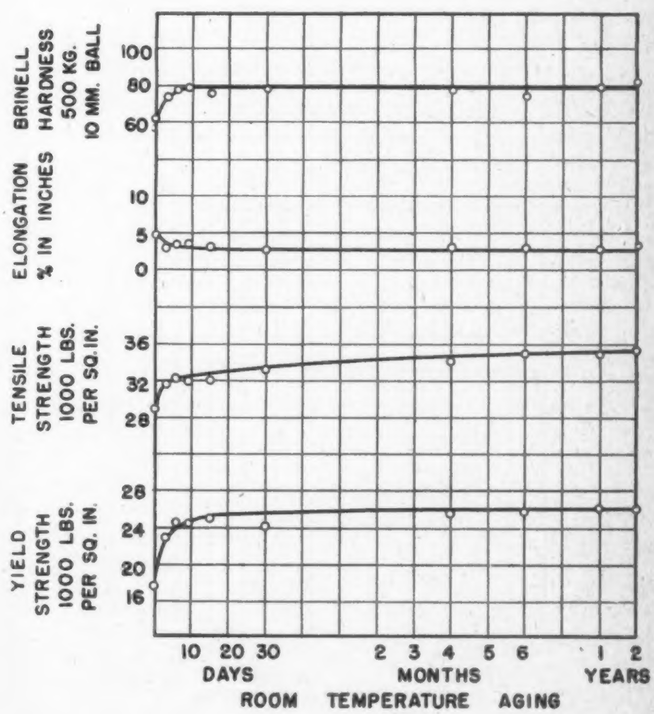


Fig. 24—Effect of room temperature aging on the mechanical properties of solution heat treated sand cast No. 355 aluminum alloy standard ½-in. diameter test specimens.

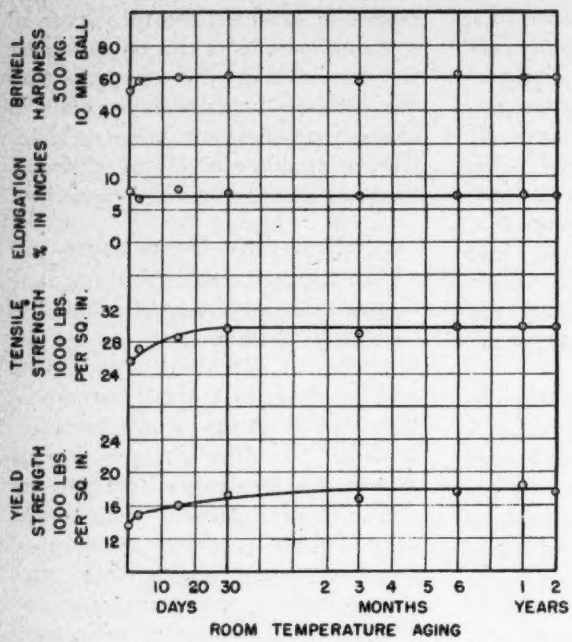


Fig. 25—Effect of room temperature aging on the mechanical properties of solution heat treated sand cast No. 356 aluminum alloy standard ½-in. diameter test specimens.

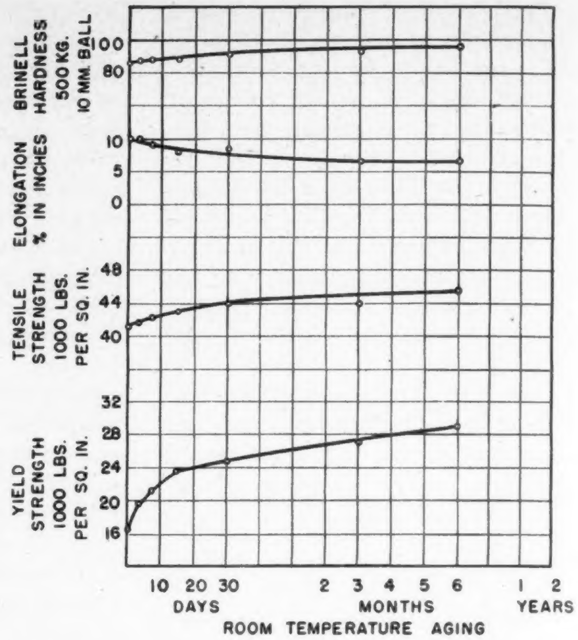


Fig. 26—Effect of room temperature aging on the mechanical properties of solution heat treated permanent mold No. B195 aluminum alloy standard ½-in. diameter test specimens.

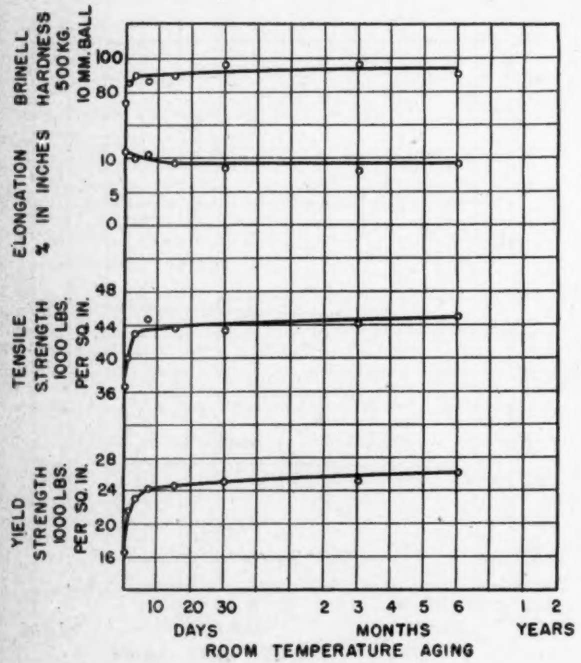


Fig. 27—Effect of room temperature aging on the mechanical properties of solution heat treated permanent mold No. 355 aluminum alloy standard ½-in. diameter test specimens.

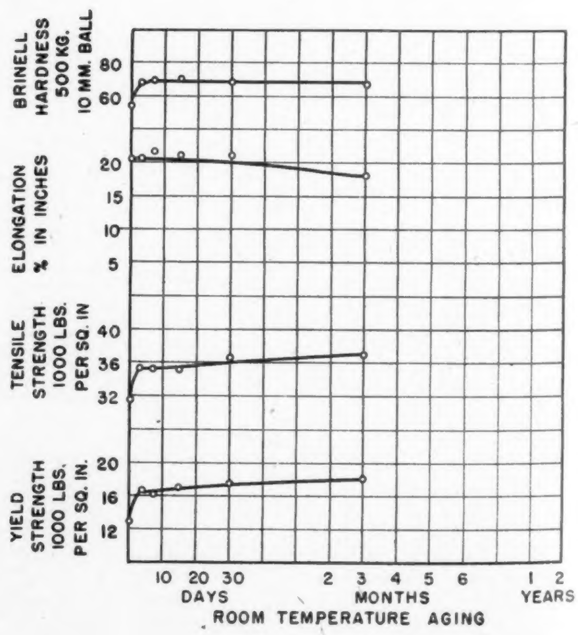


Fig. 28—Effect of room temperature aging on the mechanical properties of solution heat treated permanent mold No. 356 aluminum alloy standard ½-in. diameter test specimens.

attendant higher tensile and yield strengths and lower elongation. Other aging treatments effect a compromise, providing somewhat lower tensile and yield strengths and hardness than are obtained with the foregoing treatments in order to retain higher elongations.

A third type of aging treatment is an intermediate temperature treatment following a solution treatment. The higher aging temperatures that are used produce an overaged material. As the term implies, overaging results in precipitation in excess of that which imparts maximum hardness and tensile strength. The objective of these treatments is to procure substantial freedom from growth in castings that are to be operated at elevated temperatures, and substantial removal of any internal stresses.

Density changes or growth produced by aging was discussed in connection with the first type of aging treatment. Residual internal stresses may be induced during quenching by excessively rapid cooling from the solution treating temperature. Presence of such internal stresses in castings may cause distortion during machining and, in special cases, might reduce the load carrying capacity of the part. These stresses can be minimized by adherence to the proper quenching technique. They can be further reduced by use of a suitable aging treatment.

Corrosion Resistance

Some of the physical properties of aluminum casting alloys are a function of their thermal condition. The resistance to corrosion of wrought products of certain aluminum alloys is influenced by heat treating practices[8].

In general, differences in heat treatment or heat treating practices do not alter the resistance to corrosion of aluminum alloy castings to a degree that is of importance commercially. The thermal and electrical conductiveness of aluminum castings are materially influenced by heat treatment. Conductivity data on commercial casting alloys in different thermal conditions are available[9] for use in considering applications in which these physical properties are important.

Room Temperature Aging. Reference was made, in discussing precipitation treatment, to the fact that an unstable structural condition exists in solution treated aluminum alloy castings. It was also pointed out that the rate of precipitation occurring in adjustment toward equilibrium conditions is comparatively slow at room temperature. The aging that occurs in castings at room temperature usually is most marked in the first few days after quenching from the solution heat treating temperature. It proceeds at a slower rate over a long period of time.

Curves which show the effect of room temperature aging on the mechanical properties of several solution treated commercial aluminum casting alloys are included in Figs. 23 through 28.

Some of the treatments and alloys described in the foregoing are the subject of United States patents held by the company with which the authors are associated.

References

1. J. D. Edwards, F. C. Frary and Z. Jeffries, *The Aluminum Industry,* vol. 2, Chap. III.
2. *Metals Handbook,* ASM (1939).
3. Cast Metals Handbook, American Foundrymen's Association (1944).
4. Recommended Practices for the Sand Casting of Non-ferrous Alloys, American Foundrymen's Association (1944).
5. *Alcoa Aluminum and Its Alloys,* Aluminum Company of America.
6. *Aluminum Casting Alloys,* Aluminum Company of America.
7. P. T. Stroup, "Atmospheric Control in the Heat Treatment of Aluminum Products," *Controlled Atmospheres,* ASM, p. 207 (1942).
8. F. Keller and R. H. Brown, "The Heat Treatment of 24S and Alclad 24S Alloy Products," Alcoa Technical Paper no. 9.
9. L. W. Kempf, C. S. Smith and C. S. Taylor, "Thermal and Electrical Conductivities of Aluminum Alloys," *Transactions,* AIME, vol. 124, p. 287 (1937).

DISCUSSION

Chairman: Walter Bonsack, National Smelting Co., Cleveland.

Co-Chairman: L. W. Eastwood, Battelle Memorial Institute, Columbus, Ohio.

Member: How much difference is there in mechanical properties when aging the as-cast castings and when annealing them?

Mr. Sicha: This aging or precipitation treatment performed on castings in the as-cast condition has a relatively small effect on the mechanical properties. The effect is so small as to be of relatively little commercial interest from the standpoint of attaining improvement of mechanical properties on sand castings.

It has more application on permanent mold castings and there it is performed largely with the object of changing the properties to a small degree, that is, obtaining some hardening and from that obtaining some improvement in machining characteristics. That is really its principal value.

As far as the annealing treatment is concerned, which is performed at an intermediate temperature, the mechanical properties are generally of the order of the as-cast material, although they are slightly lower in some cases, depending on alloy composition. The yield strengths may be materially reduced by annealing.

Member: I believe Mr. Sicha mentioned the fact that the smaller the macrograins, the more efficient the solution of the "B" components. Will you explain why an increase in physical properties is not obtained when adding boron to the molten metal as a grain refiner?

Mr. Sicha: The question was; with grain refining additions of boron, why is there not a greater gain in mechanical properties attained, in the light of what I said about the desirability of having fine macrograin.

That is probably explainable on the basis of heat treatment provided to the material without the boron addition. With a finer macrograin and with a fine dendritic structure, it is possible, theoretically, and in general practice, to use a shorter solution heat treating time. However, with a material that has somewhat coarser grain structure or coarser dendritic structure than is obtained when a grain refiner is added, excellent mechanical properties frequently can be obtained if sufficient solution time is used.

W. E. Martin[1]: I believe the authors made the statement that treatment at elevated temperatures produces permanent growth.

Mr. Sicha: Aging at certain elevated temperatures can be used to attain permanent growth.

Mr. Martin: I want to mention a minor exception to that statement. The alloys in the aluminum-zinc-magnesium system are not subject to such growth.

Mr. Sicha: Apparently I did not amplify some of my statements sufficiently to make clear, as has been pointed out by Mr. Martin, that growth does not occur in some aluminum alloys as a result of heating.

[1]National Smelting Co., Cleveland.

Issues Bulletin

Cleansing solution designed to remove all types of dirt and grime without injury to the skin is described in a new bulletin, "Factory Hands," issued by Stepan Chemical Co., 1353 N. North Branch St., Chicago 22, manufacturer of "ph 6." Described as "medically and chemically correct," the solution is a sulphonated oil skin cleanser, rather than a soap. Complete details are given dispensing methods for small or large organizations are shown.

HEAT TREATMENT of STEEL CASTINGS

Steel Division

War conditions restricted the activities of the Committee on Heat Treatment of Steel Castings because much of the work being done on steel castings was of a confidential nature, and these restrictions still continue at the time of this report. However, the committee has followed the developments in the field of heat treatment and briefly summarizes them in this report. In addition, it has made a survey to determine the acceptance by the foundry industry of the end-quench test for hardenability.

Widespread use of steel castings under severe wartime conditions made it necessary that optimum properties be obtained in the castings. To obtain these properties it was necessary to liquid quench many types of castings that formerly would have been normalized or annealed. Production of quenched and drawn castings presented several problems, namely:

1. Choosing a steel of chemical composition such that it would harden to the required depth in various sections during quenching.
2. Heating castings uniformly for quenching.
3. Quenching under controlled conditions.

A simple end-quench test, developed to measure the hardenability of wrought steels, was readily adapted to measuring the hardenability of cast steels. As a matter of fact, it was found that cast and wrought steels of like analyses had quite similar hardenabilities. This test enabled the foundrymen to determine rather easily the maximum thickness of section of any particular steel that would harden to the depth required for the particular application at hand. The extent to which the end-quench test was adopted is indicated in the survey at the end of this report.

Having chosen a steel of proper composition by the use of the end-quench test or by other means, it was necessary for best results that each casting made from the steel be heated uniformly to the desired temperature for quenching. This requirement led to the design and installation of heating furnaces especially designed to give uniform heating, as well as to provide improvements in the methods of loading the furnaces.

The most popular type of heating furnace has been either the batch or the semi-continuous furnace because of flexibility in handling a variety of castings. Where production warranted, a continuous heating furnace was used. In one continuous furnace, the castings were hung from rods attached to a monorail above the furnace, which had a narrow slot in the roof through which the rods extended and moved horizontally.

Water has been the almost universal medium used for quenching castings. Two quenching techniques have been widely used, namely, timed and intermittent quenching. Timed quenching consists of quenching a casting for a predetermined time before removing it from the quenching bath. Intermittent quenching is accomplished by quenching for a predetermined time, lifting the casting from the bath, allowing the temperature of various sections of the casting to equalize somewhat, and then again quenching the casting.

A survey of the end-quench test in the steel foundry industry has been the principal activity of the Committee on Heat Treatment of Steel Castings since 1944. A questionnaire, designed to elicite complete information on the subject, was compiled and sent to steel foundrymen.

Quenching Speed

Careful segregation of castings into groups that are to be quenched at one time is necessary if controlled quenching conditions are to be maintained. The speed at which a steel must be quenched to obtain the desired hardness is indicated by the "S" curve for that steel. During the past few years, "S" curves for many of the cast steels have been worked out and have served as useful guides in setting up quenching conditions. Careful attention to the design of castings so as to eliminate abrupt changes in section and sharp corners has materially aided in the production of quenched castings.

Tempering or drawing of the quenched castings has followed more or less conventional practices. Perhaps the chief difference in handling

Presented at a Steel Session of the Fiftieth Annual Meeting, American Foundrymen's Association, at Cleveland, May 8, 1946.

of quenched castings lies in the fact that they should be put into the tempering furnace as soon as possible after quenching.

Several heat-treating practices are being used for wrought steels which, to the committee's knowledge, are not widely used on castings. These are as follows:

1. Flame hardening.
2. Induction hardening.
3. Quenching into molten salt or metal baths.

The first two methods generally are used to produce a hard-surface layer on parts without hardening the entire part. They, undoubtedly, will find increased application to those castings where a hard-wearing surface backed by a tough core is needed.

Quenching into molten salt or molten metal baths is a means of eliminating cracking in parts with nonuniform sections. This method of quenching may be particularly applicable to quite complex castings. Quenching into molten salt or metal baths is also used to effect isothermal transformations so as to produce certain characteristic structures other than those obtained by quenching and drawing. The extent to which this method of quenching may be used on steel castings is not predictable at the moment.

End-Quench Test

Since 1944 the principal object of this committee has been a survey of the use of the end-quench (Jominy) test in the steel foundry industry. A questionnaire campaign was conducted to elicit as complete information as possible on the subject. The questionnaire was quite complete. It asked the purpose of the test, whether applied to research or production control; application as to product specifications; frequency of tests; source of Jominy specimen; comparisons with similar tests on wrought steels; interpretation of results; correlation with actual shop quenching practice; value of tests; and comments on the method as described in the covering ASTM specification.

The questionnaire proved to be premature, particularly as to the details sought, since the method was new to many steel foundrymen and experience was just being gathered. However, the response was gratifying and the results are considered of interest despite the fact that the report covers the situation as it existed over a year ago. Since then there has been a considerable but undetermined increase in the use of the test by steel foundrymen.

Studies looking to establishing hardenability specifications are under way by several groups, and it is probable there will soon be some formal specifications of this kind.

Results of the questionnaire are summarized as shown at right.

Only three report a consistent difference in hardenability between cast and wrought steels of similar chemistry. In view of the new generally accepted equivalence of hardenability, with similar chemistry, of cast and wrought steels, these three reports can be explained as due to limited experience with a new test.

Total questionnaires (to previously screened list)	45
Total replies (82 per cent return)	37
Replies with concrete information (71 per cent return)	32
End quench test used	
In research	18
In research and production	13
In production	1
To study new composition	25
For production control	5
Total tests per month	6 to 250
Percentage of tests on those classes or specifications tested, per cent	1 to 100
Using test to indicate	
Maximum thickness that can be hardened to required depth	11
Performance of individual heats	10
Source of end quench specimen	
Keel block	23
Special specimen	11
Checking grain size	
ASTM method	11
Special method	4
Aim to fully harden maximum casting section	10
Aim to fully harden critical zone of casting as to service conditions	13
Find end quench test helpful in this	14

Personnel of the Committee on Heat Treatment of Steel Castings is as follows: E. R. Young, *Chairman*, Climax Molybdenum Co., Chicago; N. A. Birch, American Brake Shoe Co., Mahwah, N. J.; H. H. Blosjo, Minneapolis Electric Steel Castings Co., Minneapolis; Werner Finster, Reading Steel Casting Div., American Chain & Cable Co., Reading, Pa.; R. A. Gezelius, General Steel Castings Corp., Eddystone, Pa., and C. T. Greenidge, Battelle Memorial Institute, Columbus, Ohio.

ERIE SPONSORS
Foundry Show for Public Education

INAUGURATING AN educational campaign and celebrating its first year of affiliation with the American Foundrymen's Association, the Northwestern Pennsylvania chapter sponsored a foundry show in Erie, June 5, 6 and 7. Working jointly with the Erie Foremen's Association, the chapter arranged an exhibit showing local products manufactured in great part from castings, displays of cores, molds and castings, an operating pattern shop, and several machines to demonstrate molding and coremaking. Models of furnaces and other foundry equipment illustrated the equipment in common use in modern foundries. The Erie Y.M.C.A. donated the lobby, two gymnasiums, and a large meeting room for the show.

The purpose of the Erie foundry exhibit was three-fold: (1) to acquaint the public with one of Erie's major economic mainstays; (2) to show job seekers the number and variety of openings available in the foundry industry; and (3) to acquaint youngsters with the possibilities for a future in the foundry. Interest of youngsters was stimulated by an essay contest, in addition to the other features of the show. Prizes of $25, $15 and $10 were offered for the best essays on "Why I Would Like to Work in a Foundry."

The difference between the Erie foundry exhibit and the biennial exhibit at the A.F.A. National Convention was explained by Frank Wartgow, exhibits manager, A.F.A. National Office, Chicago, who in Erie said that, "The national show allows suppliers to exhibit their products for the benefit of foundrymen, while the Erie show is educational and sponsored by foundrymen for the general public."

The exhibit was formally opened by a radio broadcast at 12:30 pm, June 5 by R. W. Griswold, Jr., Griswold Manufacturing Co., Erie, chairman of the exhibit, and immediate

(Concluded on Page 80)

PATTERNS

in a PRODUCTION FOUNDRY

G. A. Pealer
Pattern Shop Supt.
Elmira Foundry Co., Inc.
Elmira, N. Y.

IT IS PROBABLE THAT the first pattern was made by an artist in an attempt to capture the beauty of a form or figure. In doing this the artist was thinking of only one casting. It did not occur to him to make the pattern so that it would mold easily. His aim was to reproduce all the irregularities of his model and, in fact, to add a few in order to demonstrate his consummate skill.

Cost Unimportant

Undoubtedly the pattern was a solid, one-piece affair made of clay. The molding element probably was a clay or plaster of sorts that dried or set over the pattern and was removed by breaking away—later to be reassembled and filled with metal. The artist got results, but the man hours involved were tremendous. The value of the completed casting was not measured in dollars, but in the pride and awe of a masterpiece created.

In this endeavor one person was at one and the same time creator, designer, patternmaker, molder, melter and finisher. His limits were beauty and proportion; absolute size and shape were not required. Today, those who cast metal for commercial use are faced with a much different problem, summing up somewhat in the following manner:

1. Exact requirements of metal specifications.
2. Exactness of size and shape.
3. Need of a competitive cost.
4. Delivery date to be met.

Item No. 1 deals in shrinkages of metal. All patternmakers have rules, but some have difficulty in using them properly. On small patterns the shrinkage is a minor consideration, but on large work it sometimes becomes involved. A long, thin casting will not shrink the same as one of the same length but several times thicker. Metal will not shrink the same over dry sand as it does over green sand, and this calls for a combination of shrink rules used on the same pattern. This shrink factor is the first step, and an important one.

Item No. 2 is a large order and one requiring the best thought in any organization. The patternmaker must be the guiding hand in any pattern equipment conference.

Most pattern purchasers send a print to the pattern shop with orders to make a pattern. A few purchasers specify the kind of pattern, and still fewer detail the kind of equipment and just how it is to be made. This type of purchaser usually is one of the larger companies having in its organization a planning department. Some of them do have the pattern planning "know how," but some fall far short. Therefore, it is the patternmaker's job to consider the pattern equipment to be made, and to suggest any change in part design that might help to produce a better or lower cost casting.

Suggestions Valuable

In some cases this is a difficult thing to do as some engineers feel that a suggestion of change is a reflection upon their ability and good judgment. However, the greater number know that the patternmaker's experience can be valuable.

Most patternmakers have had, at one time or another, the desire to extend a pad to a wall to eliminate a loose piece, or add a larger fillet

A patternmaker is an exalted craftsman, the greatest common denominator, as well as the least common multiple of all industrial production. A patternmaker must have the creative conception of a draughtsman designer, the practical ability of a molder, the precise skill of a machinist, the analytical judgment of a mathematician. He must create a plan, or design, with vision and ingenuity and build the idea from trade to trade with practical knowledge: thinking and forming inside and out with length, breadth and thickness—adjusting accurately all values and dimensions and producing with dextrous finality any conceivable form to be cast in metal. The products of the patternmaker's skill are truly surrounded by an aura of greatness which dignifies his right to assume a place of confidence, trust, and honor in all industrial advance and national progress.—Edward Leslie.

Presented at a Patternmaking Session of the Fiftieth Annual Meeting, American Foundrymen's Association, at Cleveland, May 9, 1946.

to reduce possible casting shrink or strain crack. However, far too many patternmakers blindly make the pattern to the drawing, with the self-righteous, smug thought that the pattern is to the drawing, regardless of the fact that it is a poor pattern entailing a high molding cost.

It should be emphasized that a good engineer will thank the patternmaker for saving money or making a better, less costly casting possible.

Item No. 3 deals with competitive cost, not only in the pattern shop but in the foundry as well. The cost of the pattern in most cases, and certainly in production work, is a small item in the overall cost picture. Therefore, a pattern equipment which will mold readily and with the foundry equipment on hand must be designed if at all possible, a factor próne to be overlooked. As an illustration: A customer sends a drawing to several shops, asking for quotations on equipment to produce 200 castings.

Shop No. 1 quotes $25 for a single, one-piece pattern.

Shop No. 2, noting that the pattern can be split, quotes $35 for a two-wood pattern.

Shop No. 3, noting that 200 castings are wanted, checks the foundry for flask sizes on hand in the pattern range, and quotes $65 for a hardwood matchboard of one pattern to fit a certain flask and, upon inquiry, finds that the casting is to be a repeat number. Shop No. 3 also quotes $165 for an aluminum matchplate of two patterns, also to fit a flask on hand.

Overall Picture

In checking costs for the various equipment, the purchaser finds that the casting cost works out as follows:

Equipment No.	*Cost*	*Casting Cost*	*Total Cost (equipment + 200 castings)*
1	$25	$1.00	$225
2	35	0.92	219
3 (wood)...	65	0.70	205
3 (metal)...	165	0.60	285

Now, it will take no time to discard the quotations of shops No. 1 and No. 2. The only thing to decide is whether or not to spend $80 more on the first order to insure a low cost on all subsequent casting orders and have a permanent metal equipment, or take the lower first cost with a fair re-order casting cost. It is unnecessary to point out that shop No. 3, while quoting a higher pattern cost, got the job and made a good impression on the purchasing agent.

Item No. 4—delivery date. It will be found that in most cases a purchaser can and will extend the time limit on patterns in order to gain a good unit cost. This is particularly true when multiple pattern equipment will enable the foundry to produce at a much faster rate.

Customer Limitations

A word of caution must be added. It would be the height of folly to design an equipment, for example, to be used with jolt squeeze machines and core blowers when the foundry is a hand shop; or to make an equipment which will produce 1,000 cores a day when the production will not be able to use 100 a day. In other words, not only production but also the mechanization of the foundry using the pattern equipment must be considered.

It has been the author's experience that cores are expensive and should not be used unless made necessary by the design. However, if a drawback can be eliminated or a parting made easier, there should be no hesitation in using a core. The patternmaker should ask himself, "If I were the molder, would I like to use this pattern?"

Molders prefer a pattern with sufficient draft, no loose pieces, and if cores are used, prints having telltales so that cores cannot be misplaced. Also, clearance strips to prevent crushing should be provided.

The company with which the author is associated has a planning procedure that works fairly well. When a request for a quotation is received, it is referred to a planning board consisting of the pattern and molding superintendents who, after deciding which foundry department will make the job, call in the mold, core and cleaning foremen involved. This group then checks for present and future production and decides on the type of equipment. This information is then entered on an estimate sheet, going into detail as to just how equipment is to be made, giving flask size, number of core boxes, special arbors and core driers.

Each foreman then enters his respective cost. The pattern superintendent then reviews the equipment and enters time and material needed to produce the desired equipment, together with the cost. This card is then given to the cost department, which figures final casting cost and submits the quotation to the customer. If the order is obtained, the reverse side of the cost card becomes a job record card, so that both estimated and actual cost are on one card. This is desirable as it gives a ready check to the pattern foreman at all times.

The patternmaker assigned to the job is encouraged to offer criticism and, if the foreman believes that a change is desirable, the planning group is called to the pattern shop and again goes over the job. Good ideas are often obtained in this way. In planning the job, rough shapes are sometimes cut out to better show partings, etc.

High production patterns are mostly of the smaller types, that is, flask work, so in this discussion pit work can be passed over with only a word of caution. The pattern must be removed from the sand, and the patternmaker should provide a means of doing this without distorting either the pattern or the mold.

Cores

Medium size work—say 40 to 200 lbs.—is a casting field requiring considerable mechanization. The type and number of castings wanted largely dictate whether the pattern will be made for a stripping, a pin life, or a rollover machine. A prime point to keep in mind is that cores cost real money and can develop into a bottleneck, but if the part can be molded faster, then cores should be added (ram-up cores if possible, since a properly made ram-up core blends with the contour of the casting and shows hardly a joint, not to mention that they are easy to locate and hold in correct position). Then too, by adding a loose piece which can be removed when the mold is nearly rammed, and placing a core before completing the ramming, it often is possible to change a difficult three-part flask job into an easily molded cope and drag, with a good saving in equipment and in cost of casting.

When planning for a set core, it should be considered that the molder must set the core properly, without a lot of filing and fitting. It is false

economy to skimp on print material. A core must have its proper foundation, the same as a building. Also, the prints should have proper telltales. If two tell-tales can be used without extra coremaking cost, the patternmaker should not hesitate to use them. Also, the cope print cannot center a large core. If necessary, use a ram-up core ring in the green sand cope in which to enter the set core. Core prints in the drag should have beads on the edges to receive any shaved sand. In this way the core setting is speeded up.

When designing the pattern, a few extra dollars should be spent to provide fillets even if a few loose pieces are added to pattern and core box. It should be remembered that the molder's time is all production and that cutting fillets takes time.

When making a pattern for a production job using cores, it is well to remember that cores do not always run true to size, due to core box wear and sand and oil conditions. To overcome this, the patternmaker should provide metal core rubbing frames so that all cores must be fitted. This sounds costly, but on a production job the molding machine sets the pace and no time can be spent by the core setters to rub, fit and try outsize cores.

Another practice some patternmakers follow is that of placing a loose piece on a pattern with one or two dowell pins—an inexpensive operation in the pattern shop, but one that should not be tolerated by the foundry unless the pattern is for emergency use for a limited run.

Loose pieces should be firmly secured to a backing piece, that is, dovetailed into the pattern. If six loose pieces of different sizes are used, then six quite different sizes or shapes of backing pieces should also be used, in this way insuring proper location of parts.

However, if the six loose pieces are duplicates, then the backing pieces should all be identical so as to save the molder's time in finding proper location.

In jolting the mold and in straight ramming, loose pieces will sometimes lift unless a pin is added to hold them down. When the pattern is large enough to allow it, mechanical means should be provided.

CHAPTER CHAIRMEN

(Continued from Page 19)

ating foundry which is jointly sponsored by the National Office and the A.F.A. Chicago chapter.

Educational activities of the Association were covered during the afternoon session. Subjects discussed were: Youth encouragement, inplant training and vocational schools, educational courses and cooperation with engineering schools. The conference succeeded in bringing the broad picture of A.F.A. educational activities to the chapter officers, with the chapter officers contributing to the subject from the experience of their own local groups.

Speaker at the dinner meeting, Wednesday evening, was Dr. Henry T. Heald, President, Illinois Institute of Technology, Chicago. His subject was "Engineering Education and the Foundry Industry." The speaker related general educational problems occurring in most colleges during the present time and urged the foundry industry to take an active part in helping colleges educate engineers by sponsoring courses, installing modern foundries, etc., as it will be of great advantage to the industry.

The program of July 25 included a discussion of the technical committee work of A.F.A. by Sil Massari, newly appointed Director of the A.F.A. Technical Development Program. Mr. Massari outlined the technical organization of A.F.A. and the work of various active committees.

Cupola Research

He reported upon the successful completion of the Cupola Research Project and its culmination in the publishing of the CUPOLA OPERATIONS HANDBOOK.

A new publication policy for A.F.A. was outlined, and illustrated as to how it would fit in with future convention papers and reports.

The morning program was rounded out with an explanation of the publishing activities of A.F.A. and of financing; both national and local.

President Shelly Wood acted as leader for the discussion of chapter membership activities during the afternoon session. President Wood praised the work of the chapter membership workers, bringing about a new record membership of 8,539 as of June 30, 1946.

Sub-Committee Finishes Foundry Course Survey

REACTION OF faculties of engineering schools to suggestions for the establishment of special courses in foundry engineering and management, as well as to a tentative curriculum* for such courses, have been favorable, it was revealed as the Sub-Committee on Special Foundry Curriculum, Joint Foundry Industry Committee on Education, held its final meeting June 20, at the Hotel Cleveland, Cleveland.

After hearing reports of members who contacted five major schools and discussing the overall picture, the sub-committee recommended to the full committee that all five be considered in connection with plans for establishment of the special courses; and, in view of the reception accorded the proposed curriculum, recommendation was made that it be used as a basis for further discussion.

Presiding at the meeting was J. M. Price, Ferro Machine & Foundry Co., Cleveland, representing the Gray Iron Founders' Society and serving as chairman of the sub-committee.

Also present were: A. C. Denison, Fulton Foundry & Machine Co., Cleveland, representing the Gray Iron Founders' Society; Anthony Haswell, Dayton Malleable Iron Co., Dayton, Ohio, S. C. Wasson, National Malleable & Steel Castings Co., Chicago, and J. H. Lansing, Malleable Founders' Society, Cleveland, all representing the Malleable society; R. L. Collier, Steel Founders' Society of America, Cleveland, representing that organization and serving as secretary of the sub-committee; H. S. Scobie, A.F.A. National Office and W. G. Gude, *The Foundry*, Cleveland, both representing A.F.A.

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*See page 138, AMERICAN FOUNDRYMAN, April, 1946.

WHITE AND GRAY IRONS

DUCTILITY AND ELASTICITY

R. A. Flinn
and
H. J. Chapin
American Brake Shoe Co.
Mahwah, N. J.

ADDITIONAL TESTS to indicate serviceability of irons of different types has been a long expressed need of the foundry industry. For example, in 1933[1] it was recognized by the ASTM that an impact specification might be effective when tensile, hardness and other existing tests were inconclusive in distinguishing among various analyses, but no completely satisfactory solution was reached.

In this paper a different measurement to indicate relative serviceability of cast irons under severe conditions is discussed: the determination of the plastic and elastic deformation accompanying stress, that is, the complete stress-strain diagram.

Preliminary service tests show that in many instances a given amount of *elongation* rather than merely a definite tensile strength is required. Furthermore, the *type* of elongation (whether plastic or elastic) can effect service life pronouncedly.

It is the purpose of this paper to point out these differences in strain behavior among irons and to indicate in a general manner the applications of this characteristic.

Since strain is a fundamental mechanical property it is dependent upon structure just as are tensile strength and hardness[4,5]. The following structures have therefore been surveyed to determine some of the variations:

White Irons

Carbon mostly as: Iron Carbide
Matrix:
a. pearlite
b. martensite + austenite
c. austenite + martensite
d. austenite (?)

Gray Irons

Carbon mostly as: Flake Graphite
Matrix:
a. pearlite
b. pearlite and ferrite
c. martensite (tempered)
d. acicular ferrite
e. austenite

Although popularly considered brittle materials, white, mottled and gray irons can be manufactured with definite elasticity and ductility as well as reproducible tensile strength and other properties. As the matrix structure is changed from pearlitic to austenitic, the plastic elongation changes from 0.0000 to 0.0500 per cent in white and mottled irons and from 0.05 to 3.0 in gray iron. Ferritic-pearlitic gray irons exhibit up to 1.0 per cent elongation. Modulus of elasticity varies from 26.0 to 10.4 x 10⁶ psi. depending upon structure.

Part II. Definition of Terms

Because of the special application of certain testing terms in the case of cast iron, definitions are given here for reference before reviewing the literature. The complete stress-strain curve, Fig. 1, has been only occasionally determined for cast iron because of the instrumental difficulty in obtaining strain at the breaking load. Recent development of the SR-4 Gage by Ruge, DeForest and others[9] has permitted accurate determination of elongation to the breaking load and in some instances after fracture. Autographic devices of somewhat lower precision are also available.

The following terms used in describing the mechanical characteristics of the various structures are shown graphically in Fig. 1, the stress-strain curve of a soft gray iron.

A. Tensile Strength (T.S.) (pounds per square inch). This may also be termed the ultimate strength. The value is slightly lower than the true tensile strength since the original diameter, rather than that at rupture, is used in the standard calculation.

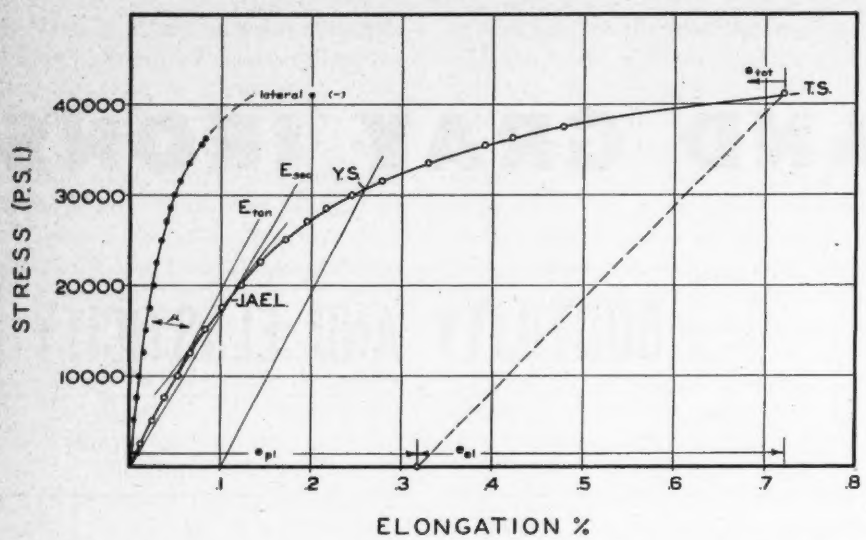
B. Elongation (e_{tot}) (inches per inch or per cent is the change in length (strain) caused by stress. At higher stresses both plastic and elastic elongation occur.

1. *Plastic Elongation* (e_{pl}) (inches per inch or per cent), Ductility. The commonest quantitative measure of ductility is plastic strain, also called permanent set. The terms will therefore be used synonymously in this discussion to describe the deformation that is not removed by unloading the specimen.

2. *Elastic Elongation* (e_{el}) (inches per inch or per cent) is the portion of the total strain which disappears if stress is removed.

C. (Tangent) Modulus of Elasticity (E_{tan}) psi. is the ratio of stress to strain at the (lower) stress values

Presented at a Gray Iron Symposium Session, Fiftieth Annual Meeting, American Foundrymen's Association, at Cleveland, May 8, 1946.



Chemical Analysis; TC, 3.48; CC, 0.84; GC, 2.64; Mu, 0.54; P, 0.27; S, 0.10; Si, 0.77 per cent.

T.S.: Tensile Strength, 41,100 psi.

e_{tot}: Total Elongation, 0.722 per cent.

e_{pl}: Plastic Elongation, 0.318 per cent.

e_{el}: Elastic Elongation, 0.404 per cent.

E_{tan}: Modulus of Elasticity, 19.5×10^6 psi.

Y.S.: Yield Strength, 0.1 per cent offset, 30,600 psi.

J.A.E.L.: Johnson's Apparent Elastic Limit: 18,000 psi.

E_{sec}: Secant Modulus: 16.8×10^6 psi.

μ: Poisson's Ratio: Lateral elastic strain/longitudinal elastic strain = 0.23.

Fig. 1—Tensile stress-strain curve of soft gray iron (AP2, Table 2) showing mechanical constants. White circles show longitudinal strain (tension). Black circles show accompanying compressive strain across specimen.

through which a straight line may be drawn. As with many other materials, e.g., brass, aluminum, the modulus changes with increasing stress. In other words, the curvature of the graph is partly due to a change in the stress to elastic strain ratio and partly to plastic strain. To average the modulus over a portion of the curve, the secant modulus (E_{sec}) is sometimes used. This modulus line may be drawn from the origin to a given percentage of the tensile strength or to "Johnson's Apparent Elastic Limit."

D. Yield Strength (Y.S.) psi. is the stress value intersected by a line parallel to the tangent modulus through 0.1 per cent or 0.2 per cent elongation and zero load. In steel this would indicate the stress with 0.1 per cent permanent deformation, but for irons less than 0.1 per cent set will have taken place at this point because of the changing modulus referred to in *C.* In some white irons with very low plastic elongation yield strength is not determinable.

E. Johnson's Apparent Elastic Limit (J.A.E.L.) psi. is the stress at which the strain rate is 50 per cent greater than at the beginning of the curve. It is determined by drawing a line through the origin with 50 per cent greater slope than the modulus. A line parallel to this but tangent to the stress strain curve locates the desired point. This value is more reproducible than the elastic limit or proportional limit.

F. Poisson's Ratio (μ) *Ratio* inches per inch. As a specimen elongates in the direction of tensile stress, compressive *strain* occurs across the specimen as shown by the reduction of cross section. The ratio of elastic compressive strain across the bar to longitudinal tensile strain is of importance in many calculations involving residual stresses and is included for reference.

G. Relative Effects of Elastic and Plastic Strain. The effects of elastic and plastic deformation upon casting performance may be mentioned here as a corollary to the definitions just discussed.

If (Fig. 1) the specimen is stressed the first time to just below the tensile strength 41,000 psi. for example, approximately 0.7 per cent total elongation is obtained. Of this 0.3 per cent is plastic and 0.4 per cent elastic elongation. If the load is removed the elastic strain disappears and the plastic strain, or permanent set, remains.

If the specimen is again stressed to 41,000 psi. only 0.4 per cent elongation (elastic) will be obtained during loading in contrast to the 0.7 per cent observed during the first test. This difference is important when the relative uses of structures with high elastic or high plastic elongation, as in Fig. 12, are being compared.

The more elastic materials are capable of withstanding higher *repeated* deflection of a given amount without fracture. On the other hand, it must not be assumed that plastic elongation is of significance only during the first cycle of use. For example when a casting is externally heated the inner layers may be deformed plastically in tension.

During the cooling cycle, then, as the outside tends to restore the original dimensions the interior builds up compressive strain. Upon *reheating* in the next cycle, no tensile strain is encountered until this compressive strain is *removed.* The plastic deformation of the first cycle has therefore permitted the casting to adapt itself to greater elastic strain than indicated by the tensile elastic strain portion of the stress strain curve.

Literature Review

Thum, MacKenzie, Massari, Draffin and others[1, 2, 3, 6, 7, 8] have reported the plastic and elastic deformation of various irons for transverse, tensile and compressive tests. Most of the determinations have been up to 80 per cent of the breaking load. The maximum set in tension reported by MacKenzie from Thum's article was 0.05 per cent while Massari indicated values of 0.9 per cent elongation at 20,000 psi. tension and 0.6 per cent at 50,000 psi. compression for other analyses.

Thum and Massari both indicated a correlation of set with combined carbon. It was further developed by Thum that graphite flakes acted to reduce modulus of elasticity by diminishing the section of matrix under test. Ziegler and Northrup[8] also measured deformation as part of an investigation on superheating and found no correlation with pouring temperature or carbon content. They believed that variable structural effects, not discussed, were operative.

Since the completion of the majority of the above research, new engineering irons with greatly improved tensile strength, and resistant to abrasion, growth, corrosion and

general wear have been developed. The useful characteristics of these new materials were only partially indicated by standard tensile, transverse and hardness tests; an attempt to obtain a greater knowledge of the mechanical properties based upon stress-strain relationships was therefore indicated.

Part III. Experimental Procedure

A. Preparation of Specimens. Test specimens were obtained from a variety of sources, since a large share of the work was performed to correlate mechanical properties with service performance. A number of the specimens were obtained from commercially produced castings (cupola melted) as well as from induction melted experimental test bars. The details of preparation of each sample are given in Tables 1 and 2.

B. Tensile Tests. Tensile specimens, 0.505 in. in diameter, were used in all cases with a 2-in. gage length except for some instances when a 1½-in. gage length with long fillets was employed. Since strain was measured over the central inch of the specimen no difference was encountered. Type A-3, SR-4 resistance strain gages[9] were cemented to both sides of the specimen and measured in series.

Tests were made with a hydraulic testing machine, 60,000-lb. capacity, at a crosshead speed of 0.02-0.05 in. per min. The precision of strain measurement was better than 0.0003 per cent up to 0.2 per cent and better than 0.001 per cent to beyond 1 per cent. Huggenberger extensometers were used simultaneously during some of the tests and agreed with the SR-4 gage readings within the limit of error of the extensometer.

Small amounts of shrinkage were encountered in most specimens from standard ASTM arbitration bars. This shrinkage was not observable in the tensile fracture under low magnification, but was easily seen without magnification in microspecimens cut at right angles to the fracture. The seemingly slight defect causes marked reduction of both tensile strength and strain.

In Fig. 2-A the stress strain curves of tensile specimens cut from a 1.2 in. diameter arbitration bar and from an adequately headed tensile specimen of similar section (Fig. 2-B) show that total elongation is increased 100 per cent (0.42 per cent vs. 0.83 per cent) by elimination of shrinkage. The iron, furthermore, is not considered a high shrinkage material.

Irregularity of results from the high strength nickel - molybdenum iron and the austenitic iron analyses are also caused by this variable. Curves obtained from these bars containing shrinkage are included since they are from standard specimens and indicate the general form of the first part of the curve for perfect samples (Fig. 2-A).

C. Chemical Analyses. All analyses were made from ⅛-1/16 in. cubes rather than upon drillings to prevent loss of graphitic carbon. Combined carbon was determined by the difference between the total and graphitic carbon analyses.

D. Microhardness. These determinations were made with a Tukon microhardness tester under a 25-gram load and a Vickers 136° pyramidal diamond indenter. A sliding stage was used which allowed location under the microscope of the desired area for testing.

E. Concentrated Compression (Mushroom) Tests. Behavior under heavy concentrated compressive loading was investigated by using conical specimens, as illustrated in Fig. 3. The small flat area (0.060-in. diameter) at the end of the reduced section is pushed against a large surface ground martensitic

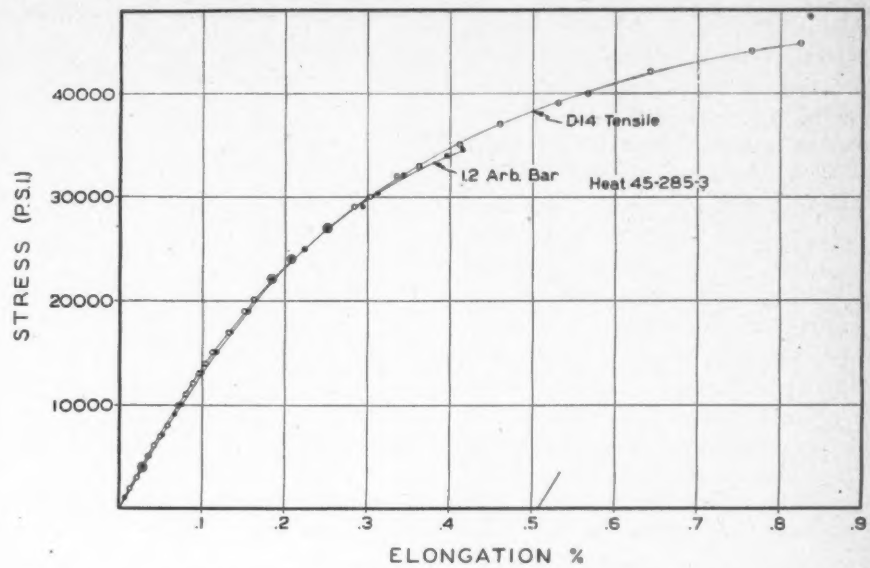


Fig. 2 (A)—Tensile stress-strain curves of 0.505 in. diameter tensile specimens for 1.2 in. diameter arbitration bar (solid circles) and properly risered D-14 specimen (open circles). High carbon nickel-molybdenum iron. Chemical analysis; TC, 3.66; Mn, 0.94; P, 0.10; S, 0.06; Si, 1.82; Ni, 1.52 Mo, 1.06 per cent.

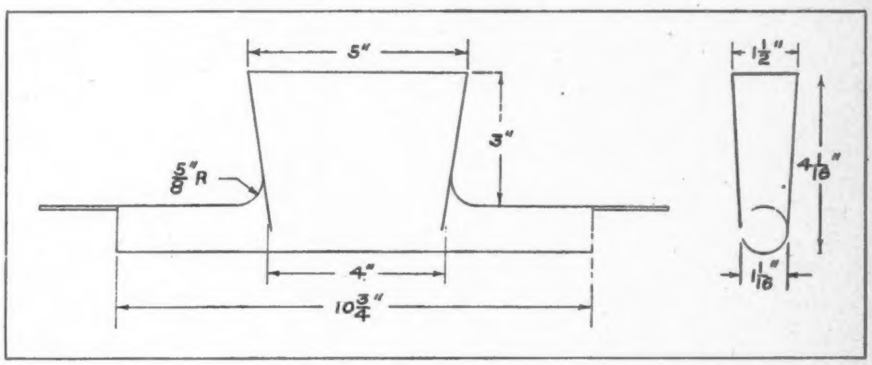


Fig. 2 (B)—Sketch of casting D-14 for obtaining single cast tensile bar. A 1 1/16 in. diameter x 10¾ in. long test bar is provided from which the tensile specimen is machined with the gage length located in the sound metal directly under the head.

white iron block in the same testing machine as used in the tensile tests. The test affords an opportunity to observe marked plastic deformation and the details of structural damage in compression and shear.

F. Creep Tests. Creep tests were conducted as described by Fellows, Cook and Avery[10] and are included to illustrate the high temperature ductility of gray iron.

G. Impact Tests. Unnotched impact specimens, 4 × 0.707 × 0.707 in., were broken transversely as Charpy specimens, in a pendulum type impact testing machine. Effective span of the specimen was 3.25 in. Data are also given for Izod tests upon 1.2 in. arbitration bars, unnotched, struck 3 in. above supports.

Part IV. Discussion of Results

The stress-strain curves and other results will be discussed in the following order progressing from the white irons of less than 0.0005 per cent plastic strain to gray irons of over 3.0000 per cent plastic elongation.

A. White and Mottled Irons
1. Effect of Matrix
2. Effect of small amounts of graphite

B. Gray Irons
1. Effect of Matrix
   a. Pearlite
   b. Pearlite-Ferrite
   c. Tempered Martensite
   d. Acicular Structure
   e. Austenite

C. Miscellaneous Tests of Plastic Deformation
   a. Microhardness
   b. Mushroom (concentrated stress) Tests
   c. Creep Tests

IV-A. White Irons— Table I, Figs. 4, 5, 6, 7, 8.

1. Effect of Matrix. In progressing from pearlitic white iron Heats 44-434, 44-440, to austenitic-martensitic irons, Heat 44-441 the plastic deformation increases from less than 0.0005 per cent to 0.0083 per cent despite the increase in hardness from 450 to 650 BHN.

Since the precision of measurement is closer than 0.0003 per cent, this represents a significant change. Modulus of elasticity exhibits a slight decrease from 25.5-26.5 × 10^6 to 24.2-24.8 × 10^6. Charpy impact strength is improved.

Table 1

Stress Strain Relationships in Various White and Mottled Irons

Reference No.	General Description	Structure: Carbon	Structure: Matrix	Chemical Analysis, per cent: TC	CC	GC	Mn	P	S	Si	Ni	Cr	Casting	Tensile Strain, psi.	Total Strain, per cent	Elastic Strain, per cent	Plastic Strain, per cent	Tangent Modulus of Elasticity, Psi.x10^6	BHN., As Cast: Surface	BHN., As Cast: Center	Impact, ft.lb. Charpy .707[3]
44-434	1.5% Cr White Iron	Carbide	Medium Pearlite	3.40	3.37	0.03	0.62	0.05	0.07	0.68	—	1.55	[1]1-in. Y	46,000	0.1780	0.1780	0.0000	26.0	495	460	6.5
				Tempered 500° F.—8 hr.									[2]3-in. Y	34,350	0.1300	0.1300	0.0000	26.5	468	444	6.8
													[1]1-in. Y	40,250	0.1580	0.1580	0.0000	25.5	—	—	5.5
44-440	1.5% Ni 1.5% Cr White Iron	Carbide	Fine Pearlite	3.43	3.39	0.04	0.72	0.05	0.05	0.62	1.58	1.54	[1]1-in. Y	35,750	0.1380	0.1380	0.0000	26.0	555	555	5.5
				Tempered 500° F.—8 hr.									[2]3-in. Y	36,750	0.1450	0.1445	0.0005	25.5	555	512	4.8
44-441	4.0% Ni 2% Cr White Iron	Carbide	85% Aust. 15% Mart.	3.41	3.36	0.05	0.74	0.05	0.05	0.66	4.02	2.02	[1]1-in. Y	31,500	0.1330	0.1250	0.0080	24.2	652	600	7.5
				Tempered 500° F.—8 hr.									[1]1-in. Y	51,250	0.2050	0.2002	0.0048	25.8	—	—	7.3
		Carbide	70% Aust. 30% Mart.	3.41	3.36	0.05	0.74	0.05	0.05	0.66	4.02	2.02	[2]3-in. Y	32,650	0.1430	0.1354	0.0076	24.7	652	600	6.8
				Tempered 500° F.—8 hr.									[2]3-in. Y	50,000	0.2020	0.1976	0.0044	25.3	—	—	7.5
44-435	4.5% Ni 1.5% Cr Mottled Iron	Carbide and Graphite	15% Aust. 85% Mart.	3.39	3.06	0.33	0.66	0.05	0.05	0.98	4.43	1.54	[1]1-in. Y	30,000	0.1310	0.1268	0.0042	24.2	600	532	9.0
				Tempered 500° F.—8 hr.									[1]1-in. Y	51,500	0.2150	0.2126	0.0024	24.8	—	—	10.5
		Carbide and Graphite	5% Aust. 95% Mart.	3.39	1.82	1.57	0.66	0.05	0.05	0.98	4.43	1.54	[2]3-in. Y	43,250	0.3629	0.3124	0.0505	18.7	555	504	11.0
				Tempered 500° F.—8 hr.									[2]3-in. Y	50,000	0.3134	0.2921	0.0213	20.5	—	—	10.3

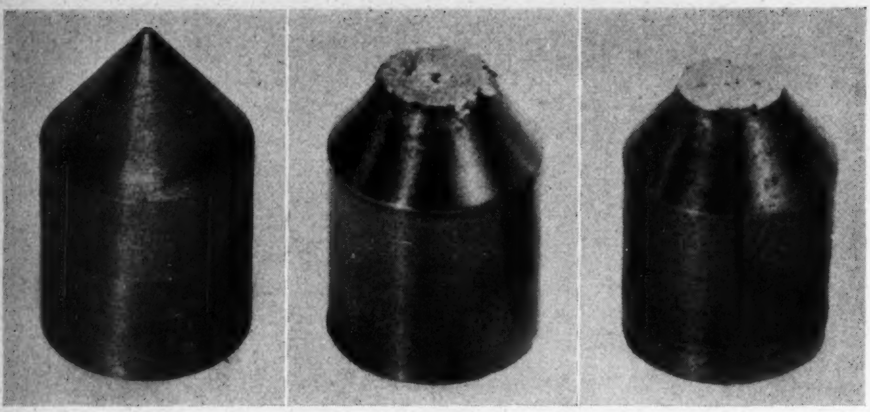
[1] 1-in. Y Block: 1 in. wide, 2⅜ in. high, 6 in. long heavily headed along top. Total Weight, 12 lb. High frequency induction furnace melted.
[2] 3-in. Y Block: 3 in. wide, 2⅜ in. high, 6 in. long heavily headed along top. Total Weight, 50 lb. High frequency induction furnace melted.
[3] 0.707 in. sq. x 4 in. long. Charpy unnotched. 3.25 in. between supports, struck centrally, 120-ft. lb. blow.

Table 2

STRESS STRAIN RELATIONSHIPS IN VARIOUS GRAY IRONS

Reference No.	General Description	Structure: Carbon	Structure: Matrix	Chemical Analysis, per cent: TC	CC	Mn	P	S	Si	Ni	Cr	Other	Casting	Tensile Strength, psi.	Total Strain, per cent	Elastic Strain, per cent	Plastic Strain, per cent	Tangent Modulus of Elasticity, psi. x10⁶	Yield Strength, 0.1 per cent offset, psi.	Poisson Ratio	BHN.
44-079-17	3%Si, 2%Cr Iron	Carbide + Graphite	Pearlite	3.10	1.20	0.98	0.10	0.10	3.57	—	1.94		D14[1]	42,500	0.360	0.293	0.067	17.3	42,000		293
44-448-17				3.54	1.15	0.99	0.13	0.11	3.38	—	1.95			28,600	0.423	0.353	0.070	10.7	26,500		235
AP1	Gray Iron, A.C. from 1600° F.	Graphite	Fine Pearlite	3.48	0.84	0.54	0.27	0.10	0.77	—	—		Wheel[2]	42,800	—	—	—	20.2	31,000	0.24	194
AP2														41,100	0.722	0.404	0.318	19.5	30,600	0.23	194
BP2	Mold cooled		Med. Pearlite	3.46	0.82	0.49	0.27	0.10	0.60	—	—			40,300	0.916	0.429	0.487	19.3		0.23	187
EP1	Mold cooled, Higher Si		Medium Coarse Pearlite	3.48	0.81	0.58	0.29	0.11	0.87	—	—			37,700	—	—	—	19.2	24,000		165
EP2														42,800	—	—	—	17.1	24,500	0.24	165
X1	Cooled 10° F./hr. from 1600° F.		Coarse Pearlite + Ferrite	3.49	0.60	0.47	0.29	0.11	0.60	—	—			31,000	—	—	—	17.5	19,000	0.22	130
X2														29,700	—	—	—	17.3	18,000	0.23	130
CP1	Same, higher Si			3.48	0.44	0.55	0.30	0.13	0.72	—	—			28,300	—	—	—	15.0	18,000	0.22	124
45-005B				3.51	0.40	0.61	0.07	0.08	1.05	—	—			17,750[3]	1.359	0.279	1.180	12.0	13,000		103
FP1	Heat treated[5] Gray Iron		Tempered Martensite and Acicular	3.51	1.03	0.55	0.28	0.10	0.72	—	—			64,000	0.530	0.416	0.104	16.9	58,000	0.22	321
FP2														59,000	0.462	0.392	0.070	17.1	55,800	0.24	321
M405	Acicular Ni-Mo[6] Iron, Low C		Acicular	2.34	0.65	0.88	0.02	0.02	2.64	2.93	0.25	Mo 0.97	1.2 in.[4]	78,250	0.643	0.455	0.188	17.7	65,000		375
406														71,500	0.559	0.434	0.125	17.7	65,000		418
403	Same tempered 500° F.-15 hr.		Acicular Tempered											84,250	0.584	0.491	0.093	17.6	84,000		402
404														93,125	0.721	0.570	0.151	17.6	83,000		430
45-285-3	High C Ni-Mo Iron		Acicular	3.66	—	0.94	0.10	0.06	1.82	1.52	0.03	Mo 1.06	D14[1]	44,700	0.824	0.510	0.314	14.0	32,000		235
407	14%Ni, 6%Cu, 2%Cr[6] Austenitic Iron	(Some Carbide)	Austenite	2.93	0.97	1.52	0.17	0.02	2.03	14.28	1.82	Cu 6.04	1.2 in.[4]	21,400	1.980	0.350	1.630	12.2	14,300		101
408														22,700	2.332	0.362	1.970	12.2	14,300		112
409	20%Ni, 2%Cr Austenitic Iron			2.91	0.79	1.51	0.11	0.03	1.68	20.45	2.11			23,250	2.326	0.296	2.030	12.9	15,200		116
410														25,200	3.096	0.336	2.760	12.9	15,200		114
411	18%Ni, 3%Cu, 2%Cr 50% Steel Charge			2.89	0.85	1.21	0.09	0.03	1.81	18.38	2.28	Cu 2.74		31,750	1.692	0.341	1.351	14.9	20,500		140
412														33,900	2.215	0.361	1.854	14.9	20,500		143
413	30%Ni, 3%Cr Austenitic Iron			2.49	0.48	1.08	0.21	0.13	1.61	30.34	3.04			25,200	1.202	0.270	0.932	12.3	18,300		118
414														27,250	1.615	0.295	1.320	12.3	18,300		137

[1] D14 Bar, 1$\frac{3}{16}$ in. dia. by 10¾ in. long, poured horizontally through heavy head over central 4 in. of bar. High frequency induction furnace melt—as cast.
[2] Specimens cut from plate section (1½ in. thick) of experimental 750-lb. wheel. Cupola melted.
[3] Same as (2) but induction furnace melt.
[4] 1.2 in. arbitration bar cast vertically in dry sand. Specimens contained microshrinkage.
[5] Water quenched 1500° F. to 700° F., air cooled.
[6] Izod impact over 120 ft./lb. (1.2 in. arbitration bar struck 3 in. above supports).



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Left to right: Specimen before testing; gray iron test specimen after loading to 56,000 lb.; spheroidized mottled iron specimen after loading to 42,000 lb.

Dimensions of original specimen: Angle of truncated cone, 60°; diameter of flat at small end, 0.060-0.62 in.; diameter of base of cone and cylindrical section, 1.000 in.; length of cylindrical section 1.00 in.

Fig. 3—Concentrated compression (mushroom) test specimens.

Tempering of the austenitic-martensitic structures at 500° F. for 8 hr. increases tensile strength from 35,000 to 50,000 psi., and decreases ductility 30-50 per cent. Pearlitic irons are not significantly affected since no change in structure occurs.

Impact strength of the austenitic-martensitic structure shows only slight improvement with tempering —an indication that the decreased plastic deformability diminishes the effect of the increased elastic elongation and tensile strength.

2. *Effect of Graphite (Mottled Iron)*—Table I, Heat 44-434. Increase of silicon and nickel and decrease in chromium causes the expected partial graphitization of the carbide structures, Fig. 8 (in the one-in. section, 0.33 per cent graphitic carbon, and in the 3-in. section, 1.57 per cent average graphitic carbon are obtained (Heat 44-434, Table 1)).

The effect of graphite in the small section in increasing ductility is more than counterbalanced by a decrease in austenite from 85 per cent to 15 per cent (estimated plastic elongation is lowered from 0.0080 to 0.0042 per cent).

However, the greater graphitic carbon in the heavy section causes 0.0505 per cent plastic elongation despite the largely martensitic matrix. A decrease in modulus from 24.2-25.8 $\times$ 10^6 to 18.7-24.2 $\times$ 10^6 psi, is also apparent and is attributed to the presence of graphite.

Tempering of these graphitic structures at 500° F. shows the same effects as in the graphite-free specimens: increased tensile strength but diminished ductility (by 50 per cent).

IV-B. Gray Irons—Effect of Matrix

1. *Pearlite*—Table 2, Figs. 9, 10. The substitution of graphite for the massive carbide of pearlitic irons previously discussed (Fig. 9) increases the plastic deformation (from 0.0000-0.0005 per cent to 0.0500-0.5000 per cent), decreases the tangent modulus (from 25.5-26.5 $\times$ 10^6 psi. to 12.0-19.3 $\times$ 10^6 psi.), and may increase tensile strength under proper conditions of graphite distribution. Hardness is, of course, reduced. Irons with hypereutectoid combined carbon content, Fig. 9, are less ductile (0.1 per cent set) than eutectoid (0.5 per cent set) compositions.

2. *Pearlite-Ferrite*—Table 2, Fig.

Fig. 4—Photomicrograph of pearlitic white iron (L 91303).

Chemical analysis: TC, 3.40; CC, 3.37; GC, 0.03; Mn, 0.62; P, 0.05; S, 0.07; Si, 0.68; Ni,—; Cr, 1.55 per cent.

Microhardness readings (left to right): Vickers hardness 248,355 (pearlite); (855,730) 1080, 1080, 990 (carbide); 295, 268 (pearlite) (855) carbide; 320, MnS and carbide.

Section of 1-in. Y block. Heat No. 44-434. Etchant; 3 per cent Nital, 8 sec. 500X. BHN.—495.

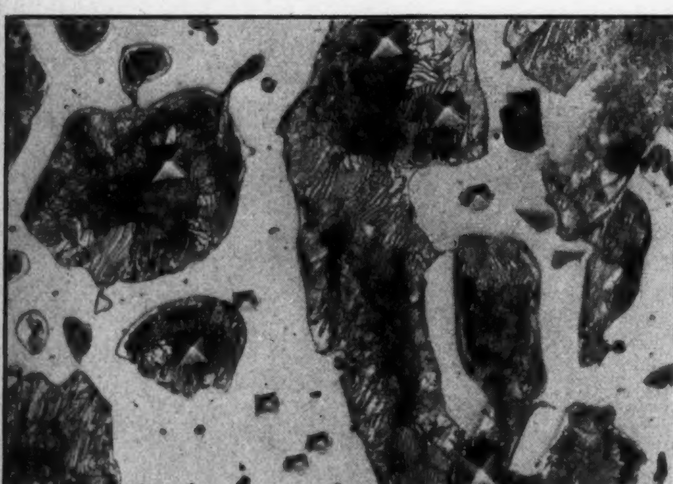
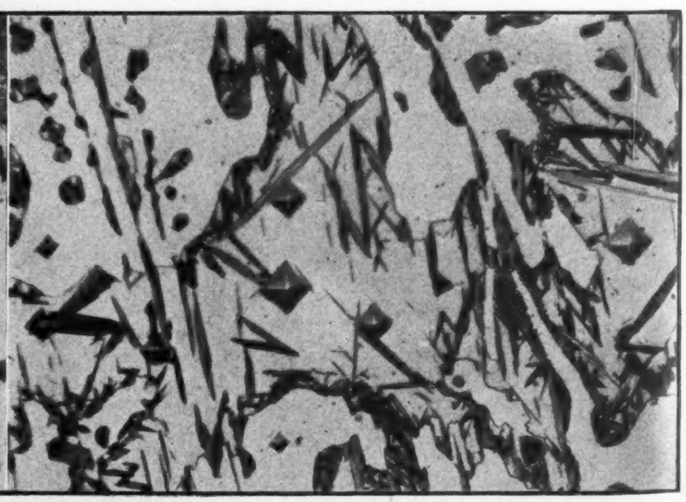


Fig. 5—Photomicrograph of martensitic white iron (martensite, austenite, carbide) L 91603.

Chemical analysis: TC, 3.41; CC, 3.36; GC, 0.05; Mn, 0.74; P, 0.05; S, 0.05; Si, 0.66; Ni, 4.02; Cr, 2.02 per cent.

Microhardness (Vickers hardness Nos.): austenite-martensite, 595-390; Carbide, 1320-1130.

Section of 1-in. Y block. Heat No. 44-441. Etchant; 3 per cent Nital, 8 sec. 500X. BHN.—652.



10. As combined carbon is decreased (from 0.84 to 0.40 per cent) and corresponding amounts of ferrite appear, tensile strength declines (from 42,800 to 17,750 psi.) and plastic deformation increases (from 0.318 to 1.180 per cent).

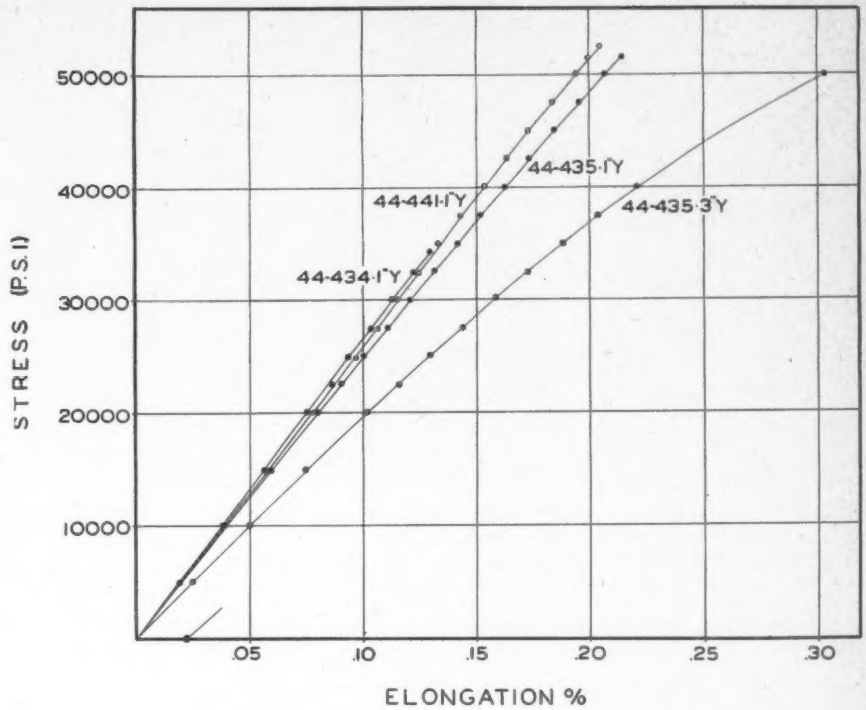
Total strain is greater than for higher strength irons, but the elastic component of the strain is less (1.359 vs. 0.722 per cent total, 0.404 vs. 0.279 per cent elastic strain, respectively). The coarser pearlite in the lower combined carbon irons may also have contributed to the above effect.

3. Tempered Martensitic—Acicular Structures—Table 2, Fig. 12. In contrast to the ferritic pearlitic structures, 45-005B, tempered martensite, FP-2, shows high strength (60,000 psi. in the case selected) but less than 10 per cent of the ductility. However, if plastic deformation is to be avoided, higher stresses may be sustained with the latter iron without encountering appreciable set. For example, yield strength at 0.1 per cent offset is 45,000 psi. for the martensitic material vs. 13,000-19,000 psi. for pearlitic (Table 2).

4. Acicular Structure—Figs. 11, 12, Table 2. Greater strength and ductility were obtained in the low carbon acicular structures, Fig. 11, than in the high carbon tempered martensites, despite greater hardness (93,125 psi. maximum tensile and 0.151 per cent permanent set vs. 64,000 psi. and 0.104 per cent permanent set). The effect of tempering upon the plastic properties of the acicular structure is not evident, probably because of the effect of shrinkage in the test bar discussed in Part II.

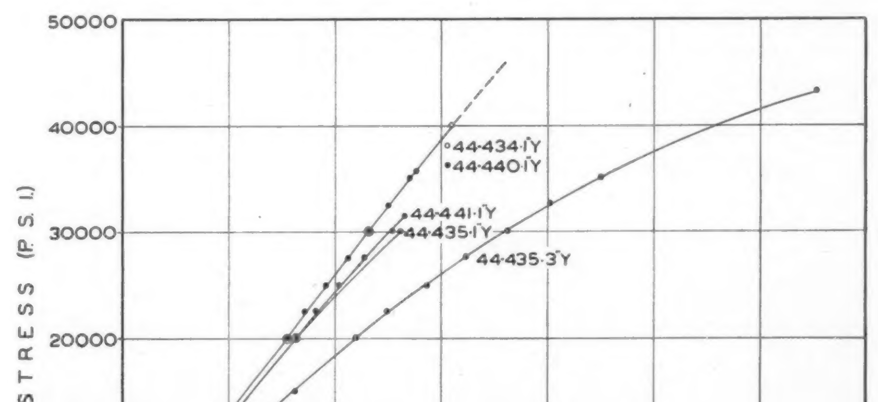
The high carbon, acicular, nickel-molybdenum iron (Fig. 12) indicates that strength and modulus are materially decreased by the increased carbon content.

5. Austenite. The austenitic gray irons (M-407-414, inclusive) containing 14-30 per cent nickel with 2-3 per cent Cr are the most ductile tested, possessing permanent elongation of 1-3 per cent. This is parallel to the characteristics of austenite in white irons previously mentioned and in austenitic steels. The variation between specimens is attributable to pronounced microshrinkage in the test bars.



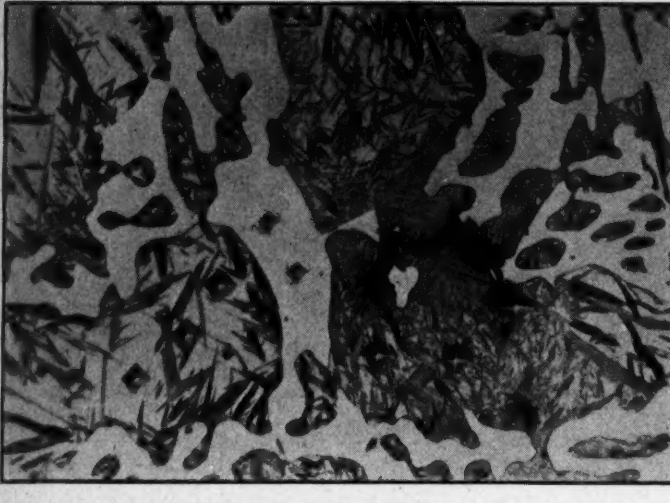
Reference No.	Chemical Analysis, per cent TC	CC	GC	Mn	Si	Ni	Cr
44-434 1-in. Y	3.40	3.37	0.03	0.62	0.68	—	1.55
44-441 1-in. Y	3.41	3.36	0.05	0.74	0.66	4.02	2.02
44-435 1-in. Y	3.39	3.06	0.33	0.66	0.98	4.43	1.54
44-435 3-in. Y	3.39	1.82	1.57	0.66	0.98	4.43	1.54

Fig. 7—Tensile stress-strain curves for white and mottled irons (tempered, 500° F., 8 hr.) of different matrices (0.505 in. diameter specimen).



Reference No.	Chemical Analysis, per cent TC	CC	GC	Mn	Si	Ni	Cr	Matrix
44-434 1-in. Y	3.40	3.37	0.03	0.62	0.68	—	1.55	Pearlite
44-440 1-in. Y	3.43	3.39	0.04	0.72	0.62	1.58	1.54	Pearlite
44-441 1-in. Y	3.41	3.36	0.05	0.74	0.66	4.02	2.02	Austenite Martensite
44-435 1-in. Y	3.39	3.06	0.33	0.66	0.98	4.43	1.54	
44-435 3-in. Y	3.39	1.82	1.54	0.66	0.98	4.43	1.54	

Fig. 6—Tensile stress-strain curves for white and mottled irons (as cast) of different matrices (0.505 in. diameter specimens).



Chemical analysis: TC, 3.39; CC, 3.06; GC, 0.33; Mn, 0.66; P, 0.05, S, 0.05; Si, 0.98; Ni, 4.43; Cr, 1.54 per cent.

Microhardness (Vickers hardness Nos.) readings (left to right): 572, 520, 555 (martensite-austenite); 1600, 1500 (carbide); 635, 640, 555 (martensite).

Section of 1-in. Y block. Heat No. 44-35. Etchant; 3 per cent Nital, 8 sec. 500X. BHN.—600.

Fig. 8—Photomicrograph of martensitic white iron (slight mottle). Martensite, austenite, carbide, graphite (L 91403).

Chemical analysis: TC, 3.54; CC, 1.15; GC, 2.39; Mn, 0.99; P, 0.13; S, 0.11; Si, 3.38; Ni,—; Cr, 1.95 per cent.

Section of D-14 (1-1/16 in. dia.) tensile specimen. Heat 44-448. Etchant.; 3 per cent nital, 8 sec. 500X.

Greater elongation and lower modulus than pearlite-carbide structure (Fig. 4).

Fig. 9—Photomicrograph of pearlitic iron with free carbides (M 64101).

Tensile strengths are 20,000-34,000 psi. and generally lower than previously reported values obtained from larger test bars in which the microshrinkage at the center of the bar has less effect. The inoculated iron with a steel base charge (M411-412) possesses characteristically higher tensile strength and intermediate ductility.

IV-C. Miscellaneous Tests of Plastic Deformation

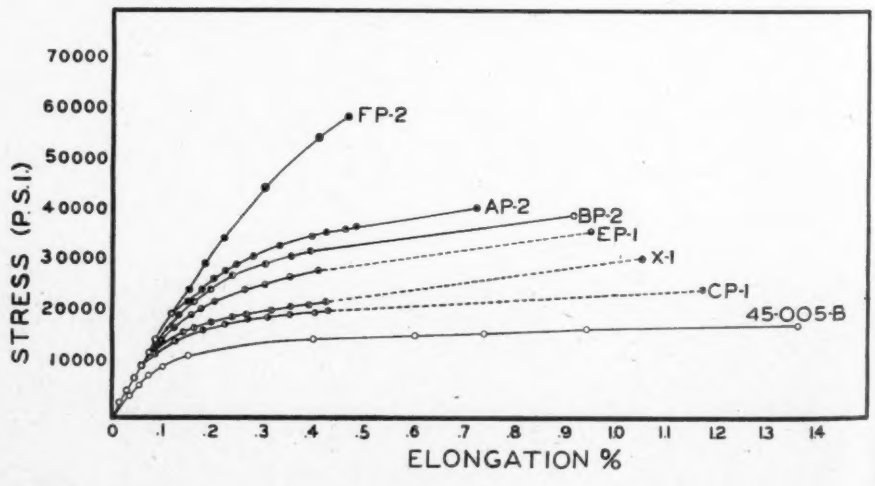
1. Microhardness. A duplex structure rarely behaves in a manner which averages the properties of the individual constituents. For example, the pearlitic white iron (Heat 44-434, Table 1) showed less than 0.0005 per cent plastic elongation, yet over 50 per cent of the structure is composed of pearlite, which if tested alone would exhibit over 10 per cent elongation.

Therefore, to supplement the standard hardness readings in which the indenter presses simultaneously upon large amounts of all constituents, the separate behavior of each phase or aggregate (such as pearlite) has been studied by use of the microhardness technique. Photomicrographs of the impressions, Figs. 4, 5, 8, 14, 15, 16, have been included to show the effects of the impression upon the metal structure, as well as the relative size of the indentations.

The data of Table 3 may be discussed as follows:

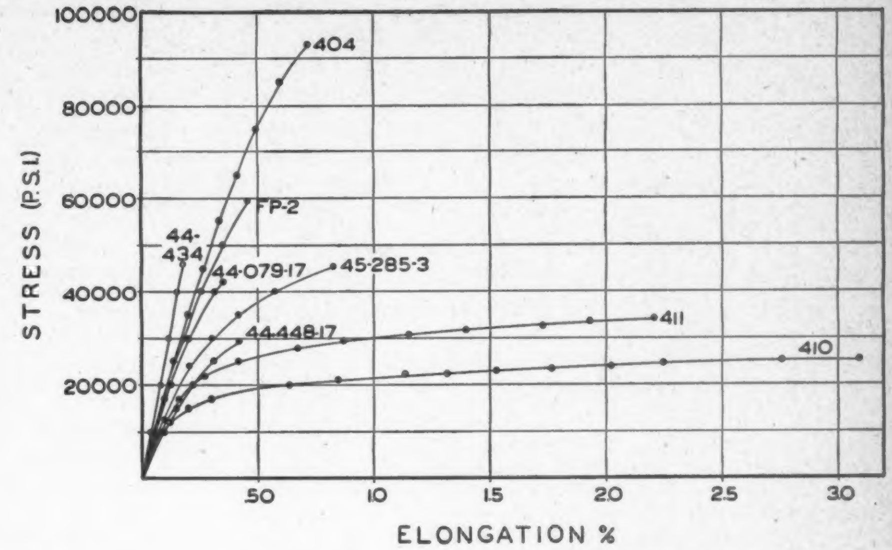
a. Carbide Hardness
b. Austenite : Austenite Martensite
c. Other Matrices : Pearlite Acicular Ferrite

a. Carbide Hardness—Figs. 4, 5, 8, 14, 15, 16. Contrary to the general impression that alloyed carbides are pronouncedly harder than iron carbide, no consistent differences in penetration hardness are evident as the total alloy content is changed from zero to 26 per cent Cr or to 4.5 per cent Ni, 4 per cent Mn, 2 per cent Cr. Hardness as measured by this method remains in the range 990-1600 VHN. (VHN. or Vickers Hardness Number is equal to BHN.,



Reference No.	Chemical Analysis, per cent TC	CC	GC	Mn	P	S	Si	BHN.	Heat Treatment
FP2	3.51	1.03	2.48	0.55	0.28	0.10	0.72	321	Quenched and tempered
AP2	3.48	0.84	2.64	0.54	0.27	0.10	0.77	194	Air cool
BP2	3.46	0.82	2.64	0.49	0.27	0.10	0.60	187	Mold cool
EP1	3.48	0.81	2.67	0.58	0.29	0.11	0.87	165	Mold cool, higher Si
X1	3.49	0.60	2.89	0.47	0.29	0.11	0.60	130	Cooled 10° F./hr.
CP1	3.48	0.44	3.04	0.55	0.30	0.13	0.72	124	Cooled 10° F./hr.
45-005B	3.51	0.40	3.11	0.61	0.07	0.08	1.05	103	Cooled 10° F./hr.

Fig. 10—Effect combined carbon upon tensile stress-strain curves of gray iron.



Heat No.	Material	TC	Si	Ni	Cr	Mo	Cu
		Chemical analysis, per cent					
44-434	1.5 per cent Cr white cast iron	3.40	0.68	—	1.55	—	—
404	High strength Ni-Mo gray iron	2.34	2.64	2.93	0.25	0.97	—
FP2	Quenched and tempered gray iron	3.51	0.72	—	—	—	—
44-079-17	3.10 per cent carbon Si-Cr heat resistant irons	3.10	3.57	—	1.94	—	—
45-285-3	High carbon Ni-Mo gray iron	3.66	1.82	1.52	—	1.06	—
44-448-17	3.54 per cent carbon Si-Mo heat resistant iron	3.54	3.38	—	1.95	—	—
411	{Austenitic} 18 Ni, 3 Cu, 2 Cr	2.89	1.81	18.38	2.28	—	2.74
410	{Gray Iron} 20 Ni, 2 Cr	2.91	1.68	20.45	2.11	—	—

Fig. 12—Tensile stress-strain curves for gray irons of different matrices.

Brinell Hardness Number up to 320; above this value VHN. increases more rapidly than BHN.; example, 500 VHN.=461 BHN., 1021 VHN. = 712 BHN.).

It is of interest that the impressions upon the carbides of the austenitic gray irons (Fig. 14) exhibit nearly the same hardness as those of the white irons (Figs. 4, 5, 8) despite the small areas available for measurement and the soft matrix.

The broad range of carbide hardness may be attributed to the brittleness of this constituent, together with the lowered precision of measurement with small impressions (± 100 VHN. at 1500 VHN.), the directional properties of the carbide crystals and the unknown depth of the cementite at the location of the impression permitting possible penetration into the underlying softer structure.

b. Austenite, Austenite-Martensite—Figs. 5, 8, 14, 15. The hardness of austenite in the gray irons M407, 409, 411, 413, Table 3, varies from 163 to 243 VHN. (BHN.). Matrix microhardness in gray iron is higher than macrohardness because the graphite flakes are eliminated.

In white iron the converse is true, because carbides increase the macrohardness. The change in the matrix surrounding the impression (Figs. 14, 15, either strain hardening or transformation) indicates that even under light loads the material around the penetrator is affected.

The austenite of the highly alloyed nickel-manganese white iron, XE15D (Table 3), exhibits hardness partly characteristic of the austenitic gray irons, but the effect of the traces of martensite is quite evident in the range of readings obtained (160-348 VHN.). As increased amounts of martensite are encountered, L914, L916, the characteristic hardness of austenite is no longer evident and readings from 390 to 695 VHN. are obtained.

Hardness Variance

This effect is caused either by underlying crystals of martensite or greater instability of the austenite which causes pronounced transformation as the penetrator is applied. However, the hardness range is still related to the austenite percentage as estimated microscopically. L916: 85 per cent austenite, 15 per cent martensite, 390-595 VHN.; L914: 15 per cent austenite, 85 per cent martensite, 500-695 VHN.

c. Other Matrices—Pearlite, Acicular, Ferritic. Pearlite hardness, as in the case of steels, is related to fineness. In L913, Fig. 4, the range of 212 to 380 VHN. is quite apparently caused by spacing and orientation of the cementite plates. Nickel content produces more uniform pearlite with increased fineness and hardness, 399 to 440 VHN. This is because of the well-known effect upon austenite transformation[4].

Behavior of ferrite alone contrasts sharply with ferrite interspersed with carbide spheroids, Fig. 16, Table 3. The scattered carbides raise the hardness from 140 to 208 VHN.

Impressions upon acicular structures, Fig. 11, confirm previous conclusions that the light etching areas contain a harder austenite-martensite mixture (455-635 VHN.), and the dark etching needlelike areas have a coarser ferrite-carbide aggregate (378-555 VHN.).

Microhardness readings upon a

Fig. 11—Photomicrograph showing low carbon acicular structure (M 48601).

Chemical analysis: TC, 2.34; CC, 0.65; GC, 1.69; Mn, 0.88; P. 0.02; S. 0.02; Si, 2.64; Ni, 2.93; Cr, 0.25; Mo, 0.97 per cent.

Section of 1.2 in dia. arbitration bar from M 403. 500X. BHN. 402.

Acicular ferrite, martensite, retained austenite, graphite (tempered at 550° F.—15 hr.). Highest strength and elastic elongation obtained in this structure.

Table 3

Microhardness of Various White and Gray Iron Structures

Reference No.	Micro No.	General Description	Matrix Hardness: Type	Matrix Hardness: Range Vickers	Matrix Hardness: Av. Vickers	Carbide Hardness: Range	Carbide Hardness: Av.	Micro Hardness: BHN.	Micro Hardness: VHN.[1]
L475	L475	White Iron "0" Alloy	Ferrite alone	150-137	140	1270-1200	1220	—	—
			Spheroidized structure	217-200	208	—	—	—	—
44-434	L913	White Iron, 1.5%Cr	Pearlite	380-212	295	1400-990	1130	460	502
44-440	L915	White Iron, 1.5%Ni, 1.5%Cr	Pearlite	440-339	380	1400-1130	1270	555	649
44-441	L916	White Iron, 4.0%Ni, 2.0%Cr	15% martensite, 85% austenite	595-390	440	1320-1130	1250	600	746
44-435	L914	White Iron, 4.5%Ni, 1.5%Cr	85% martensite, 15% austenite	695-500	595	1600-1500	1500	532	608[2]
XE15D	E231	White Iron, 4.5%Ni, 4.2%Mn, 2%Cr	Austenite, trace martensite	348-160	256	1080-990	1030	482	540
L888	L888	2.5%TC, 26%Cr	Austenite ?	415-348	365	1600-1270	1400	555	649
FPI	L473	Gray Iron, quenched and tempered	Acicular, martensitic	400-355	378	—	—	—	—
		As above, cold worked	Acicular, martensitic	574-536	555	—	—	—	—
M403	M486	Gray Iron, Ni, Mo	Dark etching acicular	555-378	455	—	—	—	—
			Light etching acicular	635-455	555	—	—	—	—
M407	M488	Gray Iron, 14%Ni, 6%Cu, 2%Cr	Austenite	208-163	180	940	940	107	—
M409	M489	Gray Iron, 20%Ni, 2% Cr	Austenite	183-170	180	1030	1030	115	—
M411	M490	Gray Iron, 18%Ni, 3%Cu, 2%Cr	Austenite	243-212	227	—	—	141	—
M413	M491	Gray Iron, 30%Ni, 3%Cr	Austenite	234-217	227	—	—	128	—

[1]Converted from 3000-kg. Brinell impressions.

[2]Presence of graphite (Table 2) lower macrohardness.

quenched and tempered acicular martensitic structure, FP-1, before and after concentrated compression testing show an increase from 355-400 VHN. to 536-574 VHN. This is a further indication that appreciable work hardening occurs in cast iron.

2. *Concentrated Compression (Mushroom) Tests*—Fig. 3. In many applications the structure is subjected to concentrated compressive loading as in line or point contact (e.g., car wheel bearing upon a rail). Because of the difficulty of predicting the effect of these conditions from standard tests, a "mushroom" test has been devised and is being studied (Fig. 3).

Figure 13 and Table 4 indicate that plastic flow under these circumstances is far greater than the amount measured in the conventional tensile test.

Some flaking of both specimens takes place as maximum load is approached. Figure 13 illustrates that the graphite flakes are turned perpendicular to the direction of loading as the matrix flows. Cracking of the carbide-phosphide (steadite) is apparent, but the cracks do not extend into the surrounding metal.

From the final areas of the deformed top surfaces and the maximum load, surface pressures of the order of 200,000-300,000 psi. are obtained. At the edges of the top surface, severe stress concentration is evident and higher pressures are probable.

3. *Elevated Temperature Tests.* Elevated temperature tests were conducted upon the 3.10 per cent carbon silicon-chromium iron previously described (Table 2). Plastic deformation increased from 0.06 per cent (room temperature test) to 15 per cent when tested at 1400° F. The enhanced ductility is accompanied by marked decrease in strength, but illustrates the marked change in properties at elevated temperatures.

Part V. Review of Data and Application to Practice

Data of sections IV-A,-B,-C indicate that irons of a wide range of elastic and plastic properties are available. Referring again to Figs. 6, 9, 10, these alloys vary from the stiff pearlitic white irons which may be stressed to 35-45,000 psi. with 0.13-0.18 per cent elastic elongation and less than 0.0001 per cent plastic strain, to the comparatively ductile austenitic gray irons with 0.270-0.362 per cent elastic and over 3.0000 per cent plastic elongation at 21-31,000 psi. The high strength acicular gray irons withstand higher stress and more *elastic* deformation (0.434-0.570 per cent) than any of the other materials.

The stress-strain curves are therefore functions of the structure and provide a better evaluation than tensile strength alone. The compressive

Table 4

Mushroom Test of Gray and Mottled Irons

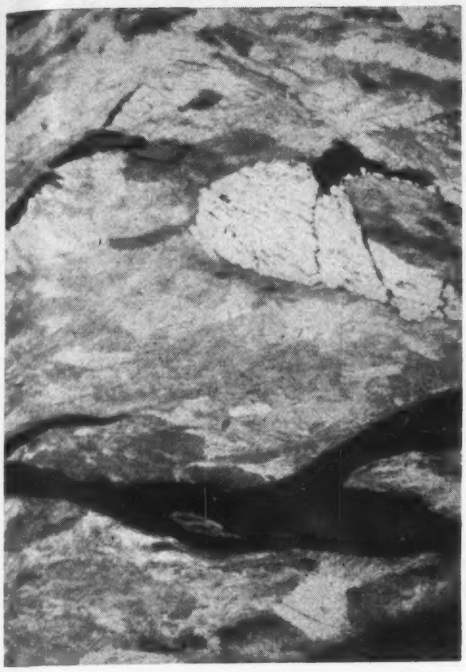
	L473 Gray Iron Martensitic Acicular	L475 Mottled Iron Spheroidized-Ferritic
Longitudinal Plastic Deformation under load, in.	0.204	0.142
Maximum Load, lb.	56,000 (no rupture)	42,000 (rupture)

Table 5

Elevated Temperature Tests of Si-Cr Iron

Chemical Analysis, per cent: TC	CC	Mn	P	S	Si	Cr
3.10	1.20	0.98	0.10	0.10	3.75	1.94

Temp., °F.	Stress Psi.	Duration of Test, hr.	Plastic Elongation During Test per cent	Remarks
70	42,500	Tensile Test	0.067	———
1000	6,000	1,000	0.7	Not carried to fracture
1200	2,000	1,000	1.3	Not carried to fracture
1200	6,000	35	6.0	Fracture
1400	1,500	93.0	15.0	Fracture
1400	2,000	81.7	12.0	Fracture



Severely worked martensitic-acicular structure containing elongated graphite flakes. (Compressive stress in vertical direction.)

Vickers hardness: Before compression—355-400; after compression—536-574 (microhardness readings).

Section of mushroom specimen from wheel FP2. Etchant—3 per cent Nital, 8 sec. 500X.

Fig. 13—Martensitic-acicular iron after compression test (L 47303).

and elevated temperature tests show that greater ductility may be obtained than indicated by room temperature tensile tests. Since the specimens melted in widely different furnaces form an orderly pattern unrelated to melting practice, the foregoing conclusions may be taken as generally applicable.

It remains now to justify the somewhat more careful technique required for determination of the complete stress-strain diagram by a review of the possible practical applications of the data. The uses may be divided into two fields:

I. Quantitative correlation of present uses of irons with different strain characteristics but similar strength.
II. Future Development.

I. Quantitative Correlation of Present Applications

Foundrymen and engineers have learned through long experience that differences in rigidity and toughness exist between white and gray irons; many proper applications have been developed on this *qualitative basis.* A brief review of the proven uses of the different structures on a quantitative basis permits a better correlation and understanding of the applications.

First, it should be decided how much plastic or elastic deformation is of importance. The *white and mottled irons* with low plasticity may therefore be considered first.

In practice, a mottled iron generally is conceded to be tougher than a white iron. In parts subject to wear, mottled irons are used successfully in the critical sections where white alloy iron would break. Figure 6 indicates that although a mottled iron (44-435-3-in. Y) is practically the same strength as a white iron, the total elongation at rupture is twice as great and plastic deformation is markedly higher (0.0505 vs. 0.0076 per cent).

Other applications where elongation rather than strength may be of paramount importance are numerous, for example, the general case of a part operating with a thermal gradient. If castings of the aforementioned irons are seated rigidly in place, elongation of 0.038 per cent is required per 100° F. temperature difference per inch.

Mottled iron will withstand over 0.3 per cent in tension or 800° F. differential, while white iron fractures at 0.15 per cent or 400° F. differential. From another point of view, white iron of 90,000-psi. tensile strength would be needed in this application to withstand the same deflection as the mottled iron.

High strength irons (60-90,000 psi.) with high elastic elongation (0.4-0.5 per cent) and some plastic deformation (0.1-0.2 per cent) have well established service records as crankshaft and camshaft materials. In this field, where the majority of failures occur in fatigue, very great ductility is of little importance. A steel with 20 per cent elongation in a static test obviously will exhibit no greater deformation than gray iron in a fatigue failure, and possesses the disadvantages of greater notch sensitivity and lower damping capacity.

Intermediate strength irons of machine tool type provide an interesting range from the fully pearlitic—tensile strength 50,000 psi., 0.70 per cent combined carbon, to the ferritic pearlitic—30,000 psi., 0.40 per cent combined carbon. As the combined carbon is decreased, softer and higher plastic elongation materials are provided with a decrease in strength and modulus.

Thermal shock resistant, ductile pearlitic-ferritic irons with below 0.20 per cent combined carbon are a logical progression from the pearlitic irons. For glass molds and ingot molds a given strain rather than strength is necessary, as explained in the section under white irons. Brake drum materials also require higher deformation and lower modulus, although combined carbon is higher (similar to 45-283-3, Table 2 and Fig. 2).

High elongation, low modulus austenitic irons offer an interesting combination of properties.

II. Future Development

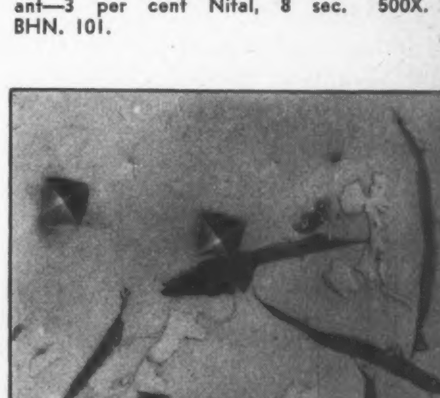
A. Effect of Structure upon Stress-Strain. Since strain evidently is complementary to stress in determining serviceability, it may be profitable to evaluate further the effects

Fig. 14—Photomicrograph showing austenitic gray iron (austenite, graphite, carbide) (L 48801).

Microhardness readings—upper left, lower right: Vickers hardness numbers, 165, 165 (austenite), 940 (carbide). Other two impressions show effects of duplex structure upon penetration.

Chemical analysis: TC, 2.93; CC, 0.97; GC, 1.96; Mn, 1.52; P, 0.175; S, 0.02; Si, 2:03; Ni, 14.28; Cr, 1.82; Cu, 6.04 per cent.

Section of tensile specimen M407. Etchant—3 per cent Nital, 8 sec. 500X. BHN. 101.



of structure upon both variables. The series of irons presented in this paper obviously is incomplete; the quantitative effects of graphite amount and distribution and of other matrices may well receive attention. The effects of phosphorus and sulphur should also be carefully defined.

Other mechanical properties of cast iron may be correlated and understood by stress-strain observations. For example, the impact strength of both the austenitic and the high strength acicular irons is in excess of 120 ft. lb. (Izod 1.2 in cast bar), yet the reasons underlying the value may be different, such as high plastic elongation in the former case, high elastic elongation and high strength in the latter.

However, from the stress-strain curve excellent strength under *repeated* impact can be predicted for the more elastic material and diminishing resistance for the less elastic. The higher damping capacity of the more ductile irons compared with the less ductile materials may also be explainable upon the basis of the greater plastic deformation at a given stress.

The loosely used term "toughness," which impact tests are intended to evaluate, may be better defined by further work as consisting of a strain and a strength component with perhaps additional consideration of notch sensitivity.

Conclusion

A survey of the different types of stress-strain curves encountered in white and gray irons indicates that strain behavior may be complementary to strength in determining the serviceability of castings. Because of the severe effects of shrinkage encountered in certain specimens prepared from standard 1.2 in. arbitration bars, it is suggested that future work of this type be conducted upon adequately fed test bars.

Acknowledgment

The authors are greatly indebted to the entire staff of the Metallurgical Department of the American Brake Shoe Co., especially to R. H. Schaefer, Earnshaw Cook and H. S. Avery for helpful criticisms and suggestions. They also appreciate greatly the metallographic work of Mrs. Eva Rule and the careful mechanical testing conducted by Misses M. A. Moran, Elaine Reuhl and S. A. Decker. The assistance of D. J. Reese of the International Nickel Co. in providing certain specimens and in criticising the work is also gratefully acknowledged.

Bibliography

1. Report of Committee XV, "On Impact Testing," *Proceedings,* ASTM, vol. 33, 1933, Part I, pp. 87-137.

2. J. T. MacKenzie, "Gray Iron-Steel Plus Graphite" (Howe Lecture) (previous thesis work), AIME *Metals Technology,* June, 1944, TP 1741.

3. S. C. Massari, "Heat Treatment—Its Effect on the Combined Carbon and Physical Properties of Wheel Iron," TRANSACTIONS, American Foundrymen's Association, vol. 47, pp. 1-39 (1939).

4. R. A. Flinn and D. J. Reese, "The Development and Control of Engineering Cast Irons," TRANSACTIONS, American Foundrymen's Association, vol. 49, pp. 559-607 (1941).

5. R. A. Flinn, M. Cohen, and J. Chipman, "The Acicular Structure in Nickel Molybdenum Cast Irons," TRANSACTIONS, ASM, vol. 30, pp. 1255-1283 (1942).

6. N. A. Ziegler and H. W. Northrup, "Effect of Superheating on Castability and Physical Properties of Cast Irons of Different Carbon Contents," TRANSACTIONS, American Foundrymen's Association, vol. 47, pp. 620-652 (1939).

7. J. O. Draffin and W. L. Collins, "Mechanical Properties of a High Strength Cast Iron," *Proceedings,* ASTM, vol. 39, 1939, pp. 589-602.

8. J. O. Draffin and W. L. Collins, "The Tensile Strength of Cast Iron," *Proceedings,* ASTM, vol. 37, Part II, p. 88, 1937.

9. C. H. Gibbons, "The Use of the Resistance Wire Strain Gage in Stress Determination," TRANSACTIONS, Soc. for Exp. Stress Analy., vol. 1, no. 1, pp. 41-46, 1943.

10. J. A. Fellows, Earnshaw Cook, and H. S. Avery, "Precision in Creep Testing," TRANSACTIONS, AIME, Iron and Steel Div., vol. 150, 1942, pp. 358-372.

DISCUSSION

Presiding: R. G. McElwee, Vanadium Corp. of America, Detroit, Mich.

Fig. 15—Photomicrograph showing austenitic gray iron (austenite, graphite, carbide L 49001).

Microhardness readings—left to right: Vickers hardness numbers, 390, 465 (carbide + austenite), 243, 222, 212 (austenite). Note slip lines in austenite adjoining impressions.
Chemical analysis: TC, 2.89; CC, 0.85; GC, 2.84; Mn, 1.21; P, 0.09; S, 0.03; Si, 1.81; Ni, 18.38; Cr, 2.28; Cu, 2.74 per cent.
Section of tensile specimen M411. Etchant—3 per cent Nital, 8 sec. 500X. BHN. 140.

Fig. 16—Photomicrograph, mottled iron no alloy (carbide, graphite, spheroidized pearlite (L 47501).

Microhardness readings—left to right: Vickers hardness numbers, 1200, 1270, 1270 (carbide), 200, 217 (ferrite + carbide), 137, 150 (ferrite).
Chemical analysis (approx.): TC, 3.50; Mn, 0.55; Si, 0.55 per cent.
Section of spheroidized chilled iron L475. Etchant—3 per cent Nital, 8 sec. 500X.

Co-Chairman: W. E. MAHIN, Armour Research Foundation, Illinois Institute of Technology, Chicago, Ill.

T. E. EAGAN[1] *(written discussion):* The authors of this paper have offered a considerable amount of fundamental data on cast iron. It is this type of information that is of great value to the design engineer in that he is given the physical constants that he can use effectively.

In addition to this, the authors in their study of the micro-hardness of the various micro-constituents have given a wealth of information to the metallurgist who is interested in cast iron. I believe that this is the first time these hardnesses have been presented in a concise form.

The modulus of elasticity is one of the physical constants that are most important to a design engineer. He uses this in his calculation of stiffness and stress. As the authors point out, this so-called constant is not constant in gray iron but changes with increasing stress.

The authors by determining the tangent modulus have given a value which is perhaps the best one to use. It no doubt is a safe one. It may also be pointed out that the actual value obtained is influenced considerably by the accuracy of the strain measurements.

The authors by the use of SR4 strain gages have taken very accurate measurements; hence the values they show are relatively low when compared to some of the results given elsewhere. The results given compare favorably with those obtained in our laboratory on comparable material.

Cast iron is usually considered a brittle material. This has come about because it does not have a great deal of plastic or elastic elongation under stress and should it break, the fracture is flat with no visible signs of any elongation or deformation. The degree of brittleness is one that needs consideration. Almost all impact tests such as Izod, Charpy, or modifications of these tests measure the amount of energy required for fracture.

No great amount of study has been made of the amount of deformation before fracture. Any great amount of plastic movement of the material will in general make the piece useless in that this will most likely affect mating parts, etc. Hence, the impact breaking strength does not have significance to the designer except in a relative way.

The important thing to the designer is the total amount of movement the material will have under a given stress. Knowing these values for various materials will help the designer choose the right material for the particular stress conditions. Brittleness will only come into the picture under very sudden impact stresses. Such impact stresses are not normal in most design considerations. Hence, the information on plastic and elastic strains given by the authors is valuable.

Chemical analyses were made using ⅛ to 1/16-in. cubes instead of drillings. Were these cubes machined from the test bars, or were they cast from the metal?

The authors should be congratulated on presenting an important subject in a clear and concise form.

H. W. LOWNIE, JR.[2] *(written discussion):* The authors are congratulated for what is, in my opinion, the most constructive and informative paper presented at the current convention. More frequent papers containing factual information of this type are sorely needed by the industry. The cast irons selected for testing have been so well chosen that the data are unusually comprehensive.

In Fig. 1, it has been indicated that unloading of the tension-test specimen from a stress just below the tensile strength will result in a reduction of strain along the dotted line until 0.318 per cent plastic strain remains at zero load. I should like to inquire how this unloading curve was determined. The confusion of plastic elongation with elastic elongation in the caption of Fig. 1 has probably been noticed by the authors.

In Part III and Fig. 2A, the difference obtained between the stress-strain curve for specimens cut from standard arbitration test bars and the risered test bars should not be overlooked by the reader. Independent data also have indicated that the traditional form of test bar leaves much to be desired.

The spread of data obtained in many investigations may well be caused simply by small amounts of unsoundness in the test bars employed and not to certain "mysterious" influences often blamed for the spread. Investigations conducted with a large number of standard arbitration test bars cast by various methods have indicated that the majority of such bars cast in commercial foundries by the recognized standard methods are probably unsound.

This unsoundness is a matter of degree, but is usually sufficient to yield erratic test results and often is enough to mask the effect of various factors that are being investigated. Unsound test bars also penalize the foundry by forcing the production of a higher strength iron in order to meet minimum tensile strength specifications.

Foundrymen who consider that their own test bars are sound might well cast ten or fifteen of their standard test bars from the same ladle of iron and determine the spread in tensile strength obtained by pulling one tension specimen from each bar. The results will probably be disconcerting.

R. W. LINDSAY[3]: I would like to compliment the authors with regard to the data that have been collected, and the presentation of it by Dr. Flinn. The subject of elastic and plastic deformation of cast iron is of definite importance. The behavior of different cast irons toward sudden thermal changes is an example of this importance.

I would like to make just a brief, additional comment. Some time ago, Massari[8] studied the stability of combined carbon in low silicon iron of the type used in the manufacture of chilled-iron car wheels when such iron was annealed for increasing lengths of time at various temperatures.

His investigation pointed out the effects of increasing amounts of ferrite (hence decreasing amounts of combined carbon) in the matrix in relation to the stress-strain behavior. This is another illustration of the importance of elastic and plastic deformation of gray iron where it relates to the mounting of railroad car wheels on axles. An iron of low combined carbon content and high plastic deformation (or set) is to be avoided in this case.

The present paper makes an important contribution by extending these studies to differences in occurrence of carbon and differences in matrices.

MESSRS. FLINN AND CHAPIN *(authors' closure):* We wish to thank Messrs. Egan, Lindsay, and Lownie for their thoughtful discussion.

In answer to the sixth paragraph of Mr. Eagan's comment, it should be noticed that while cast iron does not have as much *plastic* elongation as steel, it has greater *elastic* elongation than steel of the same strength. For example in Fig. 1, the elastic elongation for gray iron is 0.404 per cent at 41,100 psi. while a steel specimen under this load would have a maximum elastic elongation of: 41,100 psi. × 1/30,000,000 psi. = 0.137 per cent.

This greater elastic deflection may be favorable or not, depending on whether the application requires a given strain or a given stress. In reply to the ninth paragraph of the same discussion, the chemical analyses were made using ⅛ to 1/16-in. fragments machined *from the gage length* of the tensile specimen. This procedure avoids loss of graphitic carbon and will be discussed fully in a later publication.

Regarding Mr. Lownie's comment, we are inclined to agree with his stand that the present form of test bar is inadequate in providing reliable data especially for irons which require careful control of directional solidification such as white iron, and the higher strength and alloyed gray irons.

In our own experimental work we have practically abandoned the standard test bar in favor of the properly risered specimens described in the paper. We have also found it necessary to adopt non-standard test specimens to determine the effect of different section sizes encountered in the foundry which possess cooling rates far beyond those of the standard 0.875, 1.2 and 2.0-in. arbitration bars.

Concerning the determination of the unloading curve, two methods may be used:

1. The load is removed every 2,000 psi. as the breaking load is approached and the resulting points plotted on the X-axis. When the final elongation (e_{tot}, Fig.1) is obtained, a line is drawn parallel to the last unloading line and the X-intercept taken as plastic elongation.

2. When the specimen breaks just beyond the gage, a final reading is obtained at zero load to give plastic elongation. At the low elongations dealt with, elongation is quite uniform over the entire gage length.

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[2] Battelle Memorial Institute, Columbus, Ohio.
[3] Assistant Professor of Metallurgy, Pennsylvania State College, State College, Pa.

SERVICE AWARDS
Inaugurated in Hamilton Ceremonies

FOUNDRY SERVICE was recognized and honored when more than 130 employees of Hamilton Foundry & Machine Co., Hamilton, Ohio, received pins denoting five or more years association with the firm, at a recent dinner meeting in Hamilton Y.M.C.A., signalizing the first annual presentation of service pins.

Presiding at the dinner was Peter E. Rentschler, president of the company, who made the presentations, himself receiving a 25-year pin at the hands of John Nickel, oldest supervisor in point of service with 41 years association.

Topping the list of service records was that of George Feyh, who has been with the company 45 years. Also included among the 18 who received pins for 25 or more years service was Donald McDaniel, firm vice-president-secretary.

Receiving five-year pins were 73 employees; and 10, 15 and 20-year pins were presented to 15, 14 and 11 employees, respectively. Color and numerals on the shield (see cut) of the insignia differed according to length of service.

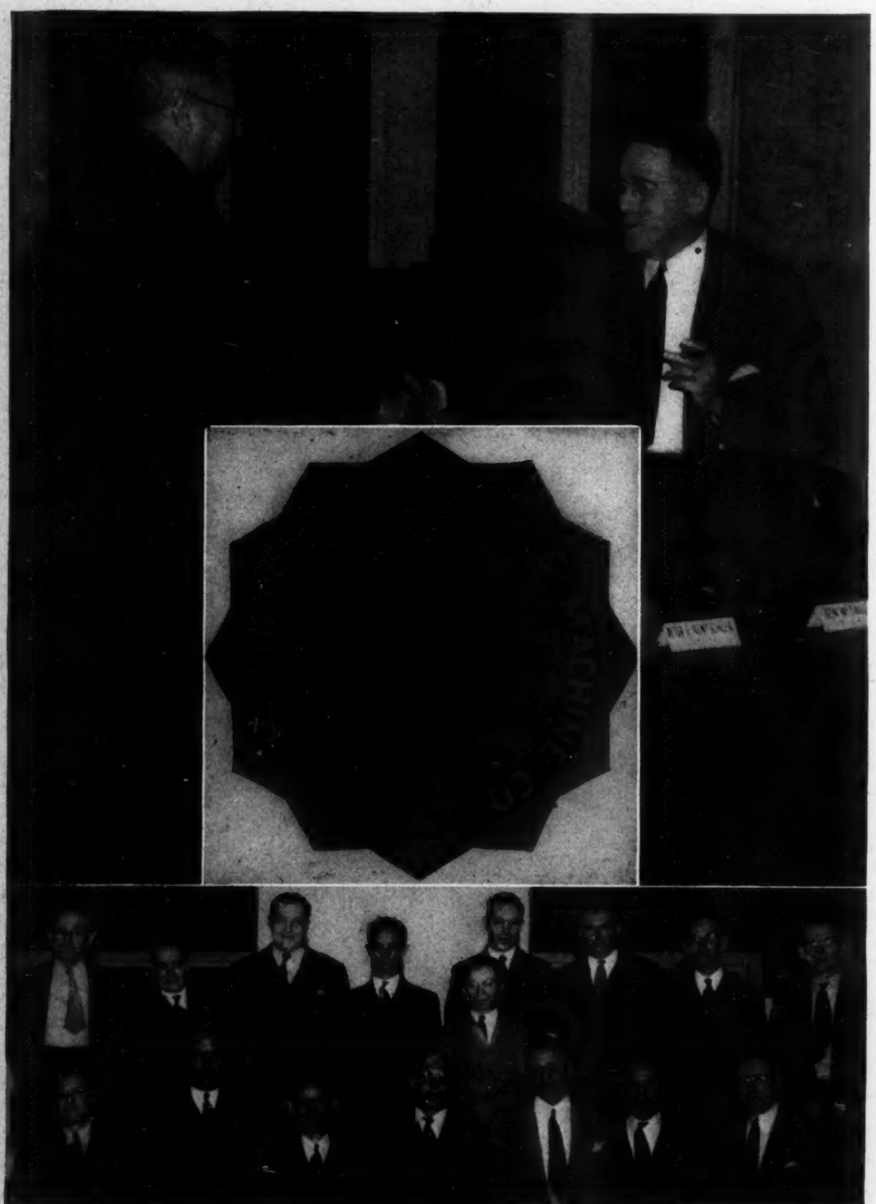
Five Years Service

In his introductory remarks prior to the presentations, Mr. Rentschler said: "It is certainly a monument to our company that about one-third of its employees have service credit of five years or more. We could never have existed 54 years without such loyalty . . .

"The army of industry . . . is a group of individuals whose work by its very nature deprives them of opportunity for glorious achievement . . . they should receive for their faithfulness a recognition beyond the value of monetary reward.

"Each and everyone of you has contributed greatly to the history of the plant. I hope each of you will continue to establish personal records of long service."

Peter E. Rentschler (left), president, Hamilton Foundry & Machine Co., presents Donald McDaniel, vice-president, with a twenty-five year service pin (inset, reproduction of pin) during recent ceremonies at which 130 company employees received service awards. Below, group awarded pins for twenty-five or more years service.



Book Review

The Metallurgy of Steel Castings, by Charles Willers Briggs, 633 pages, 334 figures. Price $6.50. McGraw-Hill Book Co. Inc., New York. 1946.

This book is of interest to every steel foundry metallurgist and every foundry instructor, and should be of value to users, purchasers and designers of steel castings. The author, Charles Willers Briggs, technical and research director of the Steel Founders' Society of America, is well known for his many contributions in the field of steel foundry practice. He has done an excellent job of correlating and organizing current steel foundry practice and literature in *The Metallurgy of Steel Castings.*

The book is well illustrated by charts, graphs and pictures. Facts in each chapter are carefully documented by extensive lists of references. It is notable that over one-fourth of the references are A.F.A. publications.

By listing many references, the author gives the serious student of steel foundry practice an opportunity to go deep into the field of steel casting metallurgy. However, the book has been limited, for the most part, to fundamentals, thus keeping it readable but highly informative.

MALLEABLE FOUNDRY

CORE SAND PRACTICE

Joseph J. Clark
Saginaw Malleable Iron Div.
General Motors Corp.
Saginaw, Mich.

ALMOST ALL SAND used in this shop for making cores is obtained from local deposits of bank sand having an A.F.A. fineness number of about 70. Figure 1 shows the sub-angular grain of this sand as compared with the round grained Ottawa silica sand.

Deposits, or pits, of bank sand occur in a relatively thin layer ranging from 5 to 15 ft. in thickness, and are covered with an overburden of topsoil. In order to extract uniform bank sand from a pit, it is essential that topsoil be thoroughly stripped away and that the proper depth and area are not exceeded in removing the bank sand. Excessively coarse sand comes from the edges and bottom of the pit.

Selection of New Pits. When a pit becomes depleted, a suitable new pit must be selected. Due to the very drastic effects which a change in sand grain size and distribution can have in coreroom practice, the selection of a new sand pit is a task requiring care and judgment. In such a case it is the custom for the sand supplier to submit a series of sand samples from prospective pits.

Grain distribution curves for these samples are determined by the laboratory and the most suitable one selected. It is the usual practice then for the sand supervisor and coreroom supervisor to visit the prospective pit, taking a new set of samples at various locations and depths.

Sieve analyses of each sample and also a composite sample are made by the sand laboratory. These are reviewed carefully. If they are suitable, and the sand is satisfactory from other standpoints, the pit is approved for use.

Control of Incoming Sand. Sand is hauled to the plant by truck in loads of from 10 to 35 tons. Figure 2 shows a plan view of the sand storage building. Trucks are able to dump the raw bank sand through an opening in the sidewall of the building into a pit which is called the truck dump.

From this dump the sand may be picked up by the 5-ton traveling crane bucket and placed in either the wet sand storage bin or, more often, directly into the 30 ton wet sand hoppers feeding the sand driers. Each of these wet sand hoppers is equipped with a heavy 4-in. mesh screen which prevents excessively large roots and other foreign matter from getting into the feeders.

In a foundry producing large volumes of castings, the econmical production of suitable cores constitutes a major problem. In the plant with which the author is associated, this fact has been recognized and a department with ample floor space, equipment, and staff has been developed to do the job. Likewise, it has been recognized that exacting control is necessary to permit the making of a large volume of cores having the proper physical properties.

Control of the incoming sand is exercised in two ways. First, a visual check is made of truckloads for excessively coarse sand, unusual amounts of lime, and presence of topsoil. Second, a grain distribution curve is plotted from a daily composite sample of sand taken at the sand drier feeders.

By means of these checks, any changes in the sand with respect to grain size, distribution, and purity may be ascertained at an early stage. Figure 3 shows a typical grain distribution curve for the bank sand. For a closer analysis of the distribution, it is the practice to use the additional sieves shown.

Sand Drying. Incoming sand from the pits varies in moisture content from 3 to 9 per cent. Accurate moisture control of core mixtures can be exercised only if the sand is dry, and cool. Raw bank sand is therefore dried and cooled before using.

Sand drying equipment consists of two parallel counterflow type driers which reduce the moisture of the sand to approximately 0.2 per cent. Each drier will dry and cool 8 tons of sand (7 per cent moisture) per hour. Increased tonnages can be run through the driers if moisture content of raw sand is lower than 7 per cent, and vice-versa.

Figure 4 shows a diagrammatic sketch of a drier and controls. Air for combustion is furnished by a small blower. The volume of air-gas mixture supplied to the firebox is

Presented at a Malleable Foundry Practice Session of the Fiftieth Annual Meeting, American Foundrymen's Association, at Cleveland, May 7, 1946.

regulated by a dual proportioning type valve which responds to the firebox temperature controller.

Surrounding the firebox is a space through which a large volume of air may be blown by the secondary blower. This space is baffled in such a manner that the secondary air must travel spirally around the box. A portion of the secondary air is allowed to enter the box through adjustable louvres at the forward end.

At the far end of the firebox the combustion products mix with the preheated secondary air and pass into the mandrel; they then double back between the mandrel and the outer drum where they are in contact with the sand.

Sand is fed into the outer drum of the drier by means of an electrical vibrating feeder. As the drum rotates, the sand is picked up by blades which lift it to the top of the drum, from which point it drops in a curtain to the bottom of the drum. Thus the sand, as it proceeds toward the mid-point of the drum, is exposed to the heated gases.

The sand and hot gases move in opposite directions (counterflow) in the heating section. As the gases proceed toward the feeding end, where they encounter wetter and colder sand, the moisture content of the gases increases and their temperature falls until they are saturated. The gases discharge from the stack at a temperature of less than 212° F. Such conditions make for high efficiency of the drier.

When the sand reaches the midsection of the drier, it is picked up and dropped into special chutes through the baffle plate into the cooling section. At this point the moisture content of the sand is about 1½ per cent. This amount of moisture is needed in order to take advantage of the cooling action arising from the evaporation of the moisture from the sand.

Cold air is blown through the mandrel in the cooling section by means of a separate blower which has been set to run at a desired constant volume. The air stream moves between mandrel and outer shell parallel to the sand flow.

Fines Removal

By adjusting the velocity of the air, fines may be carried out of the sand in varying amounts as desired. Fines, so removed, are carried by duct into a wet collector unit. Sand is discharged from the cooler at temperatures between 95° and 110° F., directly into an elevator which carries it to second floor for screening.

Operating control of the drier may be briefly described as follows: As the sand passes through the chutes from the heating to the cooling section of the drier, it drops onto a thermocouple. As shown in the sketch (Fig. 4), this thermocouple is connected to a control instrument which operates a butterfly valve on the secondary air blower intake.

Control instruments are set at a specific temperature, usually between values of 140 and 160° F. If the temperature, as measured by the thermocouple, falls, the damper on the secondary air blower opens more and thus increases the volume of cold air blown around the firebox. In turn, the firebox control instrument increases the supply of combustion gas and air due to the lowering of the firebox temperature, which normally is held at 1400° F. The increase in volume of heated air supplied to the heating section brings conditions at the midpoint of the drier back to normal. If the sand temperature at the midpoint rises, the reverse of the above actions take place.

To assist in control adjustments, temperatures of sand samples taken at the discharge end of the drier are recorded hourly. It is important to keep the sand discharge temperature between 95 and 110° F.

Sand at temperatures over 110° F. will be too hot for use, even after storage. Hot sand not only causes sticking of core mixtures in core boxes, but defeats the very purpose of drying sand by causing loss of moisture control of the mixtures through increased evaporation at the higher temperatures. Sand coming from the drier at temperatures less than 95° F. will not be thoroughly dried.

Screening. As the sand is discharged from the drier, it is taken by elevator to the second floor of the storage building where it is discharged on 20-mesh vibrating screens set at an angle of 33°. A mechanical spreader device distributes the sand evenly to permit effective screening.

Large sand grains, roots and other undesirable materials pass over the screens into the tailing chute. A periodic check of grain distribution of the tailing sand indicates the efficiency of the screens. Figure 5 is a representative grain distribution curve of the tailings, showing the presence of few sand grains finer than 40.

The usable portion of the sand falls through the screens onto a belt

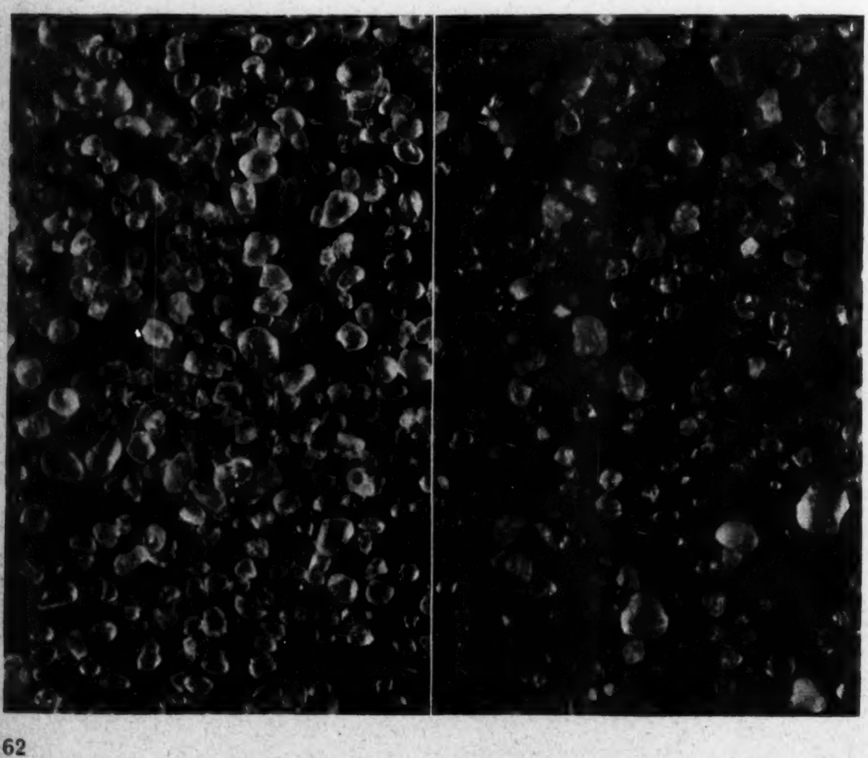


Fig. 1 (left)—Ottawa silica sand (washed and dried). (right)—Bank sand. 10X.

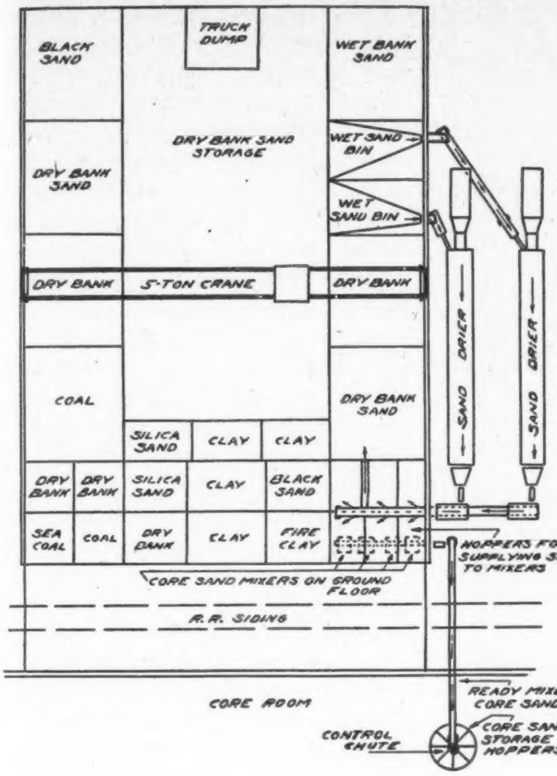


Fig. 2—Plan view of sand storage and preparation units.

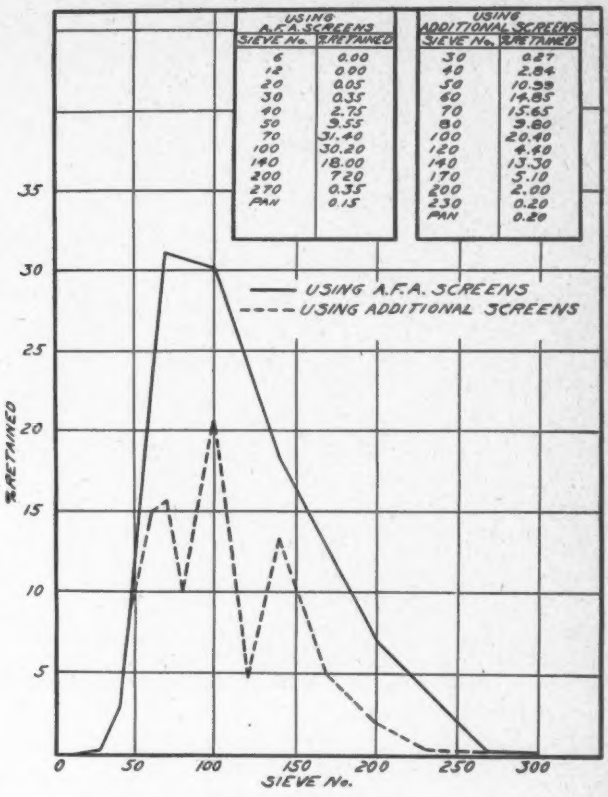


Fig. 3—Typical grain distribution curve for bank sand.

conveyor which discharges it into a 1000-ton dry bank sand bin. From this bin it is picked up by the clam bucket and transferred to a 3000-ton dry sand storage bin.

The purpose of the transferal is to blend the sand with the existing pile, thus smoothing out possible variations in grain distribution as the sand comes from the drier, and producing a more uniform sand for use. Sand from the large bin is finally transferred, as needed, to the steel hoppers above the mixers.

Selection, Storage, and Control of Other Raw Materials

Cereal Binder. Corn flour is used in the core sand mixtures to produce the necessary green compressive strength. In selecting a brand of flour, particular attention is paid to two characteristics of the flour. First, it is desirable to have a flour which develops the best green compressive strength, by test, for the least cost. Second, the characteristics of the flour must be such that core mixtures made with it have excellent "blowability" in a blow machine.

The latter characteristic is of special importance because so many of the production cores are made on blow machines. It might also be pointed out at this time that when all such factors affecting blowability are closely controlled, more and more hand-rammed jobs, and jobs of an intricate nature, can be converted to a blowing operation which, in a majority of cases, will increase production and lower costs.

It has been the experience that when the lighter flours (10 to 13 lb. per cu. ft.) are used, the core mixture will blow much better than when the heavier flours (14 to 20 lb. per cu. ft.) are used. On this basis a maximum of 13 lb. per cu. ft. has been set up as an arbitrary figure for the acceptable density of flour.

Incoming cars of flour are checked for density, and for green compressive strength developed in an emperical mixture with standard sand.

Variations in flour from shipment to shipment can cause no end of trouble in the core room if precautions are not taken in segregating

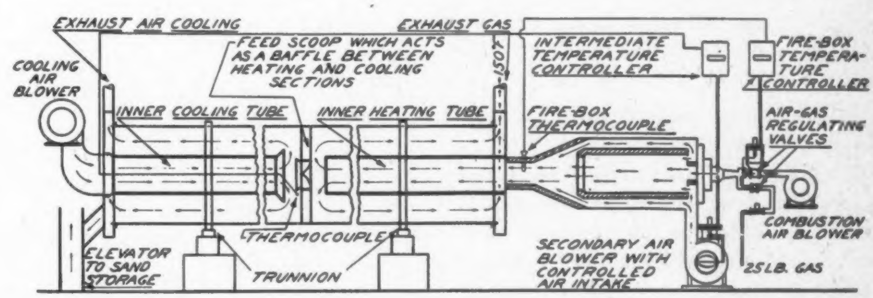


Fig. 4 (above)—Diagrammatic sketch of combination parallel and counterflow sand drier and cooler.

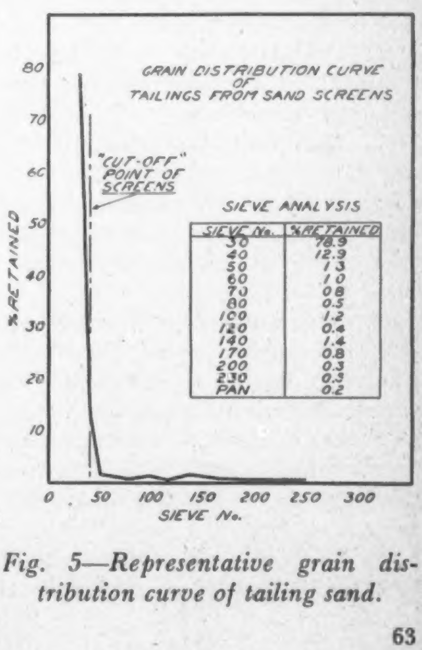


Fig. 5—Representative grain distribution curve of tailing sand.

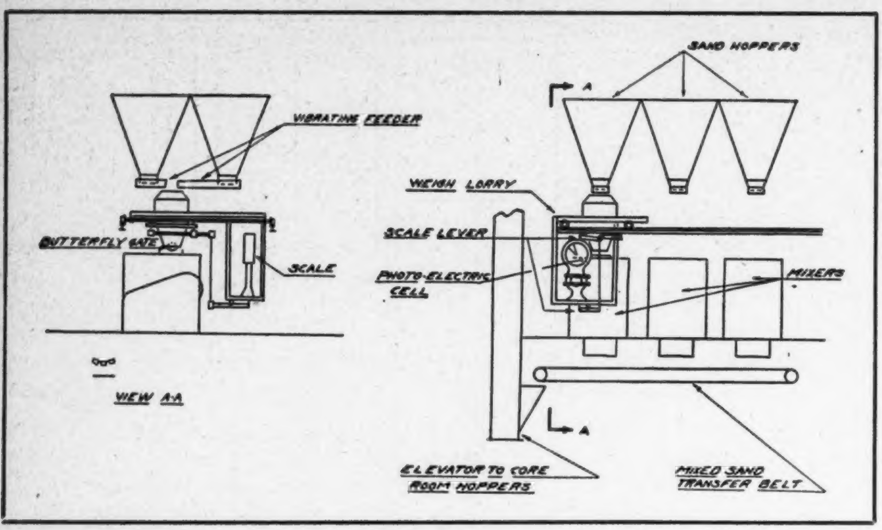


Fig. 6—Views of core sand weighing and mixing equipment.

the shipments. Moreover, if flour stands for long periods of time, or becomes damp, the green compressive strength developed by it is lower.

A system has, therefore, been established wherein the oldest flour is used first; incoming batches are piled in rotation. Flour adjustments in the core mixtures may then be made as needed, and consistent results obtained.

Core Oil. Liquid core binder, purchased in tank car lots, is used in all of the core sand mixtures. It is stored in an outside tank, from which it is pumped to the core sand mixing room in the sand storage building. The tank is equipped with steam coils to keep the viscosity of the oil at a normal level in the winter months.

In the selection of a core oil, a number of characteristics of the oil are considered:

1. Economy—Oil should be economical on a price-green compressive strength basis.
2. Uniformity—Shipment to shipment.
3. Baking — Oil should develop and maintain its maximum properties on the cycles and temperatures used in the production ovens.
4. Viscosity — Low viscosity oils are preferred due to their more thorough dispersion through the sand in a minimum mixing time.
5. Stickiness—Oil should produce a core sand mixture which permits drawing of core boxes without sticking.
6. Gas evolution—Oil should be one which develops a minimum of gas when metal is poured around the core in the mold.
7. Odor—Oils with offensive odors should be avoided.
8. Effect on skin — Oil with a strong tendency to cause dermatitis should not be used.

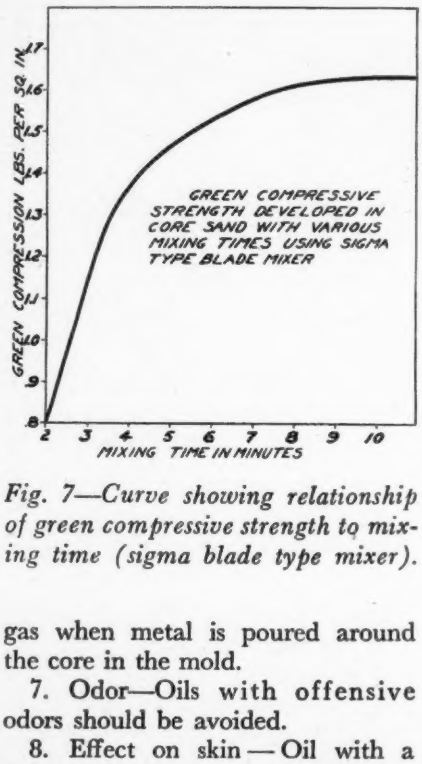


Fig. 7—Curve showing relationship of green compressive strength to mixing time (sigma blade type mixer).

Routine tests are made by the laboratory on samples of each car of oil. The sand laboratory conducts two sets of tests. One of these consists of baked tensile tests made on specimens taken from a laboratory mix using standard sand and baked in the laboratory oven. The other is identical, except that the baking is done in production ovens. The latter test is a check on baking characteristics of the oil on the production cycles being used.

Bentonite. This material is used in a few core mixtures where high green compressive strength is needed, and where the added hot strength is not detrimental. It replaces a relatively large quantity of flour in such mixes, but requires additional oil to produce a given baked tensile strength. The principal precaution in storing bentonite is to keep it dry to prevent lumping.

Iron Oxide. Iron oxide is used in several core mixtures to prevent "veining" in cored holes and, in general, produce cleaner cored surfaces in castings.

Core Sand Mixing Equipment, Mixtures and Mixture Control

Equipment. The core sand mixing equipment is located in the sand storage building directly below the series of steel hoppers containing the dried sand. These hoppers hold from 20 to 30 tons of sand each, and are refilled from the 3000-ton dry sand storage bin by means of the clam bucket.

Each of the hoppers is equipped with a vibrating electric feeder which is used to feed sand from the hopper into either of two weigh lorries (Fig. 6). Each weigh lorry is equipped with a scale and an electric eye device which will automatically stop the electric feeder on the sand hopper when the desired weight of sand is in the lorry. The lorry may then be moved along an overhead track to a position above

Table 1

Typical Core Sand Mixtures

Mixture No.	*Sand, lb.*	*Type Sand*	*Flour, lb.*	*Oil, qt.*	*Water, qt.*	*Bentonite, lb.*	*Iron Oxide, lb.*	*Moisture Standard, per cent*	*Green Compression Standard, psi.*	*Baked Tensile Standard, psi.*
1	1800	Bank	19	11	19	—	—	1.7 -1.9	1.4 -1.55	140-160
2	1800	Bank	16	12½	14	—	—	1.25-1.4	1.3 -1.45	130-145
3	1800	Bank	14	34	14	—	—	1.25-1.4	1.3 -1.45	292+
4	1800	Bank	12	12	12	—	—	1.15-1.3	1.1 -1.3	100-125
5	1800	Bank	7	31	10	—	—	1.0 -1.5	0.95-1.1	292+
6	1800	Bank	23	13	21	3	—	2.0 -2.15	2.0 -2.2	120-140
7	1800	Bank	20	9	21	3	18	2.0 -2.15	2.0 -2.2	85-100
8	1800	Bank	14½	22	14½	1	11	1.3 -1.45	1.3 -1.45	250-275
9	1050	Bank	7	7½	7	—	11	1.2 -1.4	1.3 -1.5	110-130

any one of the four core sand mixers. Sand may be discharged from the lorry through a butterfly valve into any mixer.

The sand mixers are of the kneading type having two sigma-shaped blades. Each mixer will mix 1800 lb. of sand per batch. After a batch of sand has been mixed, it is discharged onto a conveyor belt below the mixers, taken up an elevator and then carried by belt conveyor to a cluster of storage hoppers in the core room.

An electrically operated chute above the cluster of hoppers is used to divert a particular type of mixture into the proper bin. The position of the chute is remotely controlled by push buttons in the mixing room. Core sand mixtures are transported from the storage hoppers to core machines by means of tote boxes on electric trucks.

Core Sand Mixing. Once the raw materials have been properly prepared, the duplication of a given core sand mixture, batch after batch, is largely dependent upon the accuracy of weighing and measuring the ingredients, and upon the mixing practice. In practice, all dry materials are weighed and all wet materials are measured by volume.

Quantities of the ingredients to be used for each of the various types of core sand mixtures are posted in the mixing room on a large blackboard. Consequently, no excuse exists for misunderstandings between operators, coreroom foremen, or sand laboratory supervisor with regard to the ingredients of a mixture.

Mixing prodecure is set up to:

1. Feed sand from the weigh lorry into the mixer, adding the weighed amount of flour to the stream.
2. Add any other dry ingredients such as iron oxide, or bentonite.
3. Mix dry for one min.
4. Add measured amounts of water and oil in that order.
5. Mix additional 7 min. (total 8 min.), using timeclock for obtaining exact time.
6. Discharge the batch.

Adequate mixing time is of prime importance. The curve (Fig. 7) shows the relationship between mixing time and green compressive strength developed in a core mixture when using a mixer equipped with sigma blades. A number of tests were made in developing this curve, to arrive at a mixing time which would be acceptable from three standpoints:

1. Uniformity of the batch.
2. Control of properties.
3. Economy in raw materials, particularly flour.

From the curve (Fig. 7) it can be seen that only a slight increase in green compressive strength may be had beyond the 8-min. interval, but that in a shorter time much less strength is developed. Also, mixtures made with a shorter time interval have less uniformity of green compressive strength.

Obviously, by increasing the flour, high strengths could be developed quickly. However, such a practice has the following drawbacks:

1. Non-uniformity of the batch.
2. Increased cost of flour.
3. Increased flour will demand more moisture and will:

(a) Decrease blowability.

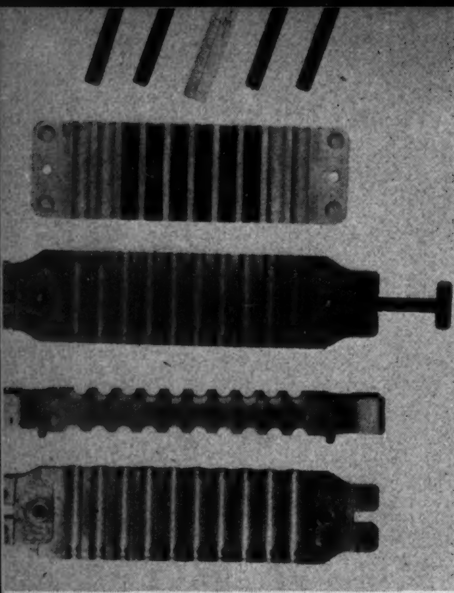
(b) Increase baking time.

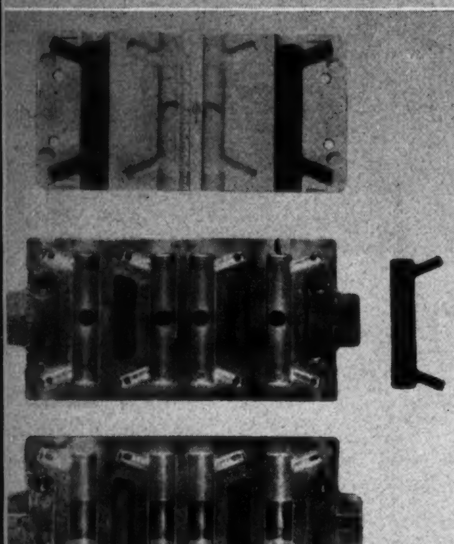
(c) Evolve more gas in the core when metal is poured about it.

Through the design of the equipment, selection and control of raw materials, core sand mixture control has intentionally been taken as much as possible out of the operator's hands. It has long been the feeling that control should never be based on the judgment, personal whims, or

Fig. 9—Making a differential case core on a special machine equipped with air-squeeze cylinder.

Fig. 8—Making a differential core on a special machine adjacent to core oven.





sense of "feel" of an operator, but should, on the contrary, be based on scientific procedures.

A number of standard core sand mixtures have been developed to take care of the major core production requirements. For these mixtures, standards have been set up for moisture, green compressive strength and baked tensile strength. Representative mixtures and the standards to which they are made are shown in Table 1.

On each shift samples of sand from each type of batch made are tested for moisture, green compressive strength and baked tensile strength. The baked tensile tests are made on briquettes baked in the standard laboratory oven at 420° F. for 1½ hours.

Briquettes are also put through the production ovens at frequent intervals as a check on production baking. On the basis of laboratory tests, adjustments are made by the sand supervisor in the various amounts of ingredients in the core mixture to maintain standards established.

An alteration in a standard for a mixture is seldom made, and then only after a thorough investigation conducted by the sand supervisor and coreroom supervisor has indicated the need for the change.

Coremaking Equipment

Efforts to control core sand mixtures as a means of speeding production of cores are nullified if core room equipment and methods are antiquated. About ten years ago our core room equipment and methods underwent a severe revamping. Further improvements are being made.

Coremaking Machines. Production coremaking machines used in the coreroom may be placed in two general classes:

1. Core blowing machines.
2. Special core machines designed in the plant, including roll-overs, roll-arounds, etc.

Reading (left) top to bottom:
Fig. 10—Three-section core box for blowing small pin cores. Aluminum drier.
Fig. 11—Core box, drier, and cores used in making an oil pump screen cover support.
Fig. 12—Four-section core box for blowing 4½ in. diesel piston head cores.

Core blowing machines are of a standard make, but have been altered to suit particular needs. Designs of the various special machines, on which many of the cores are made, are based on motion-time analysis studies of individual core jobs. Some of the features incorporated in such designs are:

1. Elevation of the sand to a position above the box so that it may be scraped into the box for filling rather than scooped up and lifted in.
2. Use of grating for removal of excess sand from bench.
3. Counterweighting and pivoting of core boxes and equipment for ease in rolling over or lifting.
4. Convenient and definite placement of auxiliary materials used in making the core (rods, chills, etc.).
5. Convenient and definite placement of all working tools such as rammers, hammers, vent wires, air hoses, etc.

Such features of design, together with the instruction of the operator in the prescribed motion paths, have been instrumental in securing high production and uniformity of cores with minimum fatigue of the operator. Figures 8 and 9 show two types of special machines being used at the present time.

Core Boxes, Driers, and Plates. The major portion of the core boxes used are made of cast aluminum with brass parting strips. Steel plates and inserts are employed in positions on the boxes where wear or erosion is encountered. Some of the boxes used in production of large quantities of small cores, and which may be suitably counterweighted in the machine, are made of gray iron.

Core driers are made of cast aluminum. Two kinds of core plates, steel and asbestos fibre boards, are in general use. Figures 10 to 15, inclusive, show a series of core boxes, driers, and cores representative of those in use at this plant.

Core Baking

Ovens designed for the greatest baking efficiency and speed are needed to produce large volumes of cores at low cost. Heating equipment for the ovens must be designed to envelop every core with a rapidly moving stream of hot air which is at a temperature sufficient to bake the core rapidly and yet not so high that

it will burn the outside of the core before the inside is baked out.

Figure 16 shows a diagrammatic sketch of a batch oven equipped with a heater of the recirculation type showing the path of the hot gases. The heating equipment used on the batch type and also the conveyor type ovens in the coreroom employ this system.

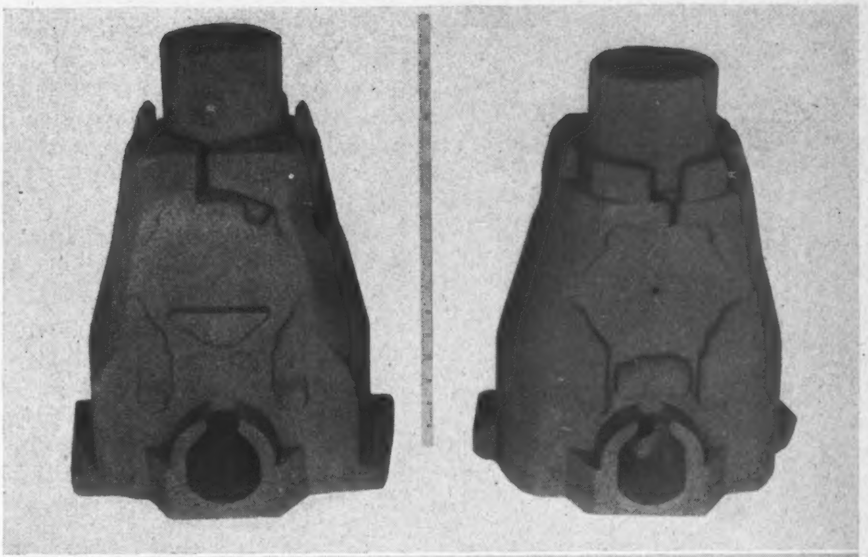
The key to fast baking in a system of this sort lies in having plenty of capacity in the recirculating fans to produce rapid change of gases in the oven in order to transfer the heat to the cores at low delivery temperatures (low temperature head).

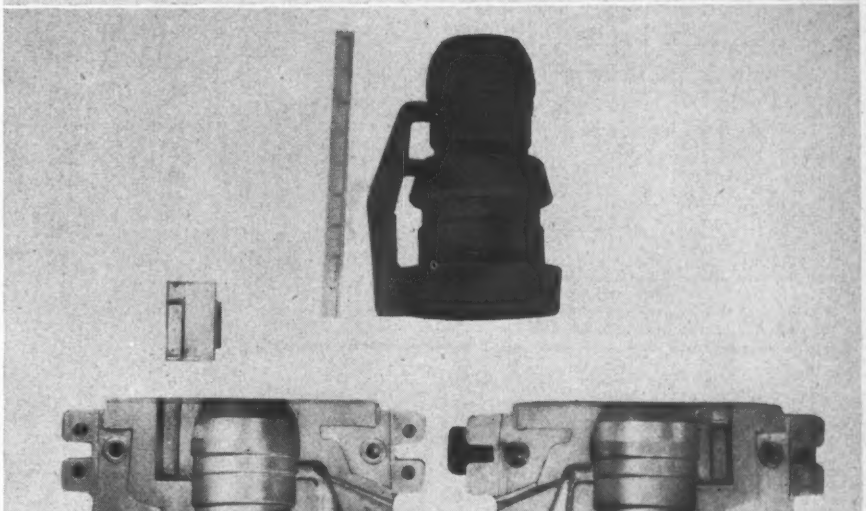
Selection of the type of oven to be used is influenced by a number of factors such as the type, size, and also number of cores to be made, the methods of making and handling cores, and the particular layout of the coreroom with respect to floor space. In this particular foundry all three of the common types of ovens (horizontal, vertical, and batch) can be used to good advantage.

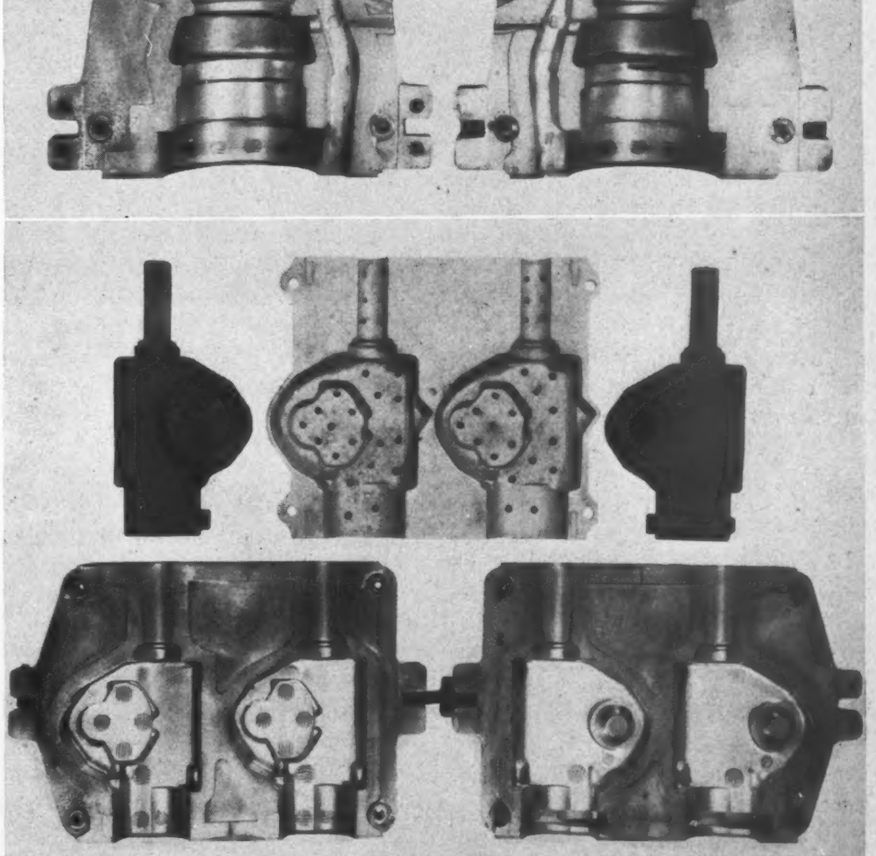
Horizontal Oven. A new horizontal oven, similar in design but of greater capacity than the old one, has been installed recently. Inasmuch as a great many coremaking stations may be placed next to the conveyor, core handling and breakage costs are reduced to a minimum with this type of oven.

Its principal use in this shop is for small cores which will bake out on a fast cycle. Blow machines and other production machines are arranged along two sections of the conveyor, as shown in Figs. 17 and 18.

The oven proper is approximately 96 ft. long, by 13 ft. wide, and is elevated to allow the use of floor space below it. A steel shroud extending beyond the exit door of the oven has been provided to permit exhausting of much of the objectionable smoke arising from freshly







Reading (right) top to bottom:
Fig. 13—Large differential carrier cores, representative of largest cores made in this foundry.
Fig. 14—Core box, and core for making pinion bearing cage casting.
Fig. 15—Steering gear housing core box, drier, and cores.

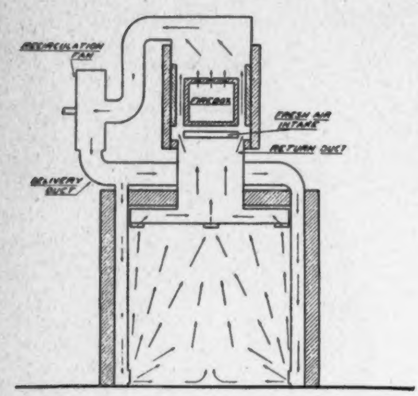


Fig. 16—Batch type core oven equipped with recirculation type heater.

part of the baking section governs the firing of these heaters. The other three heaters are similarly grouped on one manifold and are fired in response to a control thermocouple located in the midpoint of the baking section.

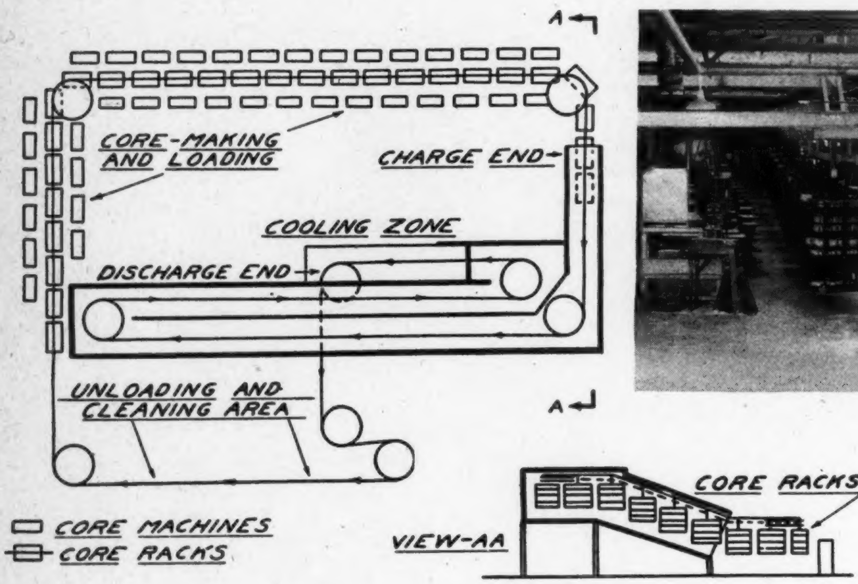
Use of two control points provides a close temperature control within the oven, and also is particularly valuable during stopping, starting, breakdowns and lunch periods; these interruptions in the cycle cause serious upsetting of temperatures in certain portions of the oven which, if not so adequately controlled, would result in underbaked or overbaked

proximately 70 ft. in over-all height and occupies a floor space 12x15 ft.

Of the 26 racks on the conveyor, 20 are in the oven (15 in baking zone, 5 in cooling zone); of the remainder, four are in the pit, one in the loading position, and one in the unloading position. Each rack will carry a total of approximately 1,600 lb. of cores, plates, and driers.

Conveyor travel is intermittent and is regulated by a timer and limit switch in the same manner as the horizontal oven.

In the case of the vertical ovens, the heater is built-in rather than being external. However, the method



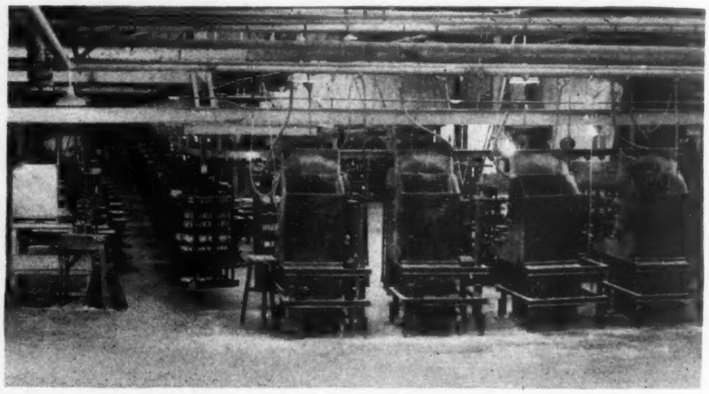


Fig. 17 (left)—Plan view of horizontal core oven.

Fig. 18 (above)—View of coremaking station and conveyor for horizontal core oven.

Fig. 19 (below)—Unloading baked cores from conveyor racks of horizontal core oven.

baked cores, and to speed core cooling to permit handling.

Of the 89 racks on the conveyor, 37 are in the baking section of the oven, and the remainder in the cooling section and at floor level in various stages of loading and unloading. Each rack is designed to carry an average load of 500 lb. of cores in addition to the weight of plates and driers. Figure 19 shows a close-up view of the racks.

Conveyor travel is intermittent, the distance which the racks move each time being equal to the distance between rack hangers. Each movement is started by an electric repeating interval timer, and is stopped by a limit switch actuated by the passage of another rack.

The oven is equipped with five external heaters of the recirculation type previously mentioned. The first two heaters are supplied from a common gas manifold. A control thermocouple located in the forward

cores. Normal temperature settings of these controllers are 450 and 470° F.

Baking time in the oven is governed by the setting of the repeating interval timer, which, as previously mentioned, determines the frequency of movement of the racks. The normal timer setting of 2 min. means about 1¼ hours ($\frac{37 \times 2}{60} = 1\frac{1}{4}$ hr.) baking time in the oven.

Vertical Core Ovens. Three vertical core ovens of almost identical construction are in use (Fig. 20). These ovens have been especially economical in the production of medium and large size cores such as differential carrier cores; in this case the tonnage production per coremaking machine is sufficiently high to permit full loading of the oven directly from a few machines located in the limited space at the entrance.

Each of the vertical ovens is ap-

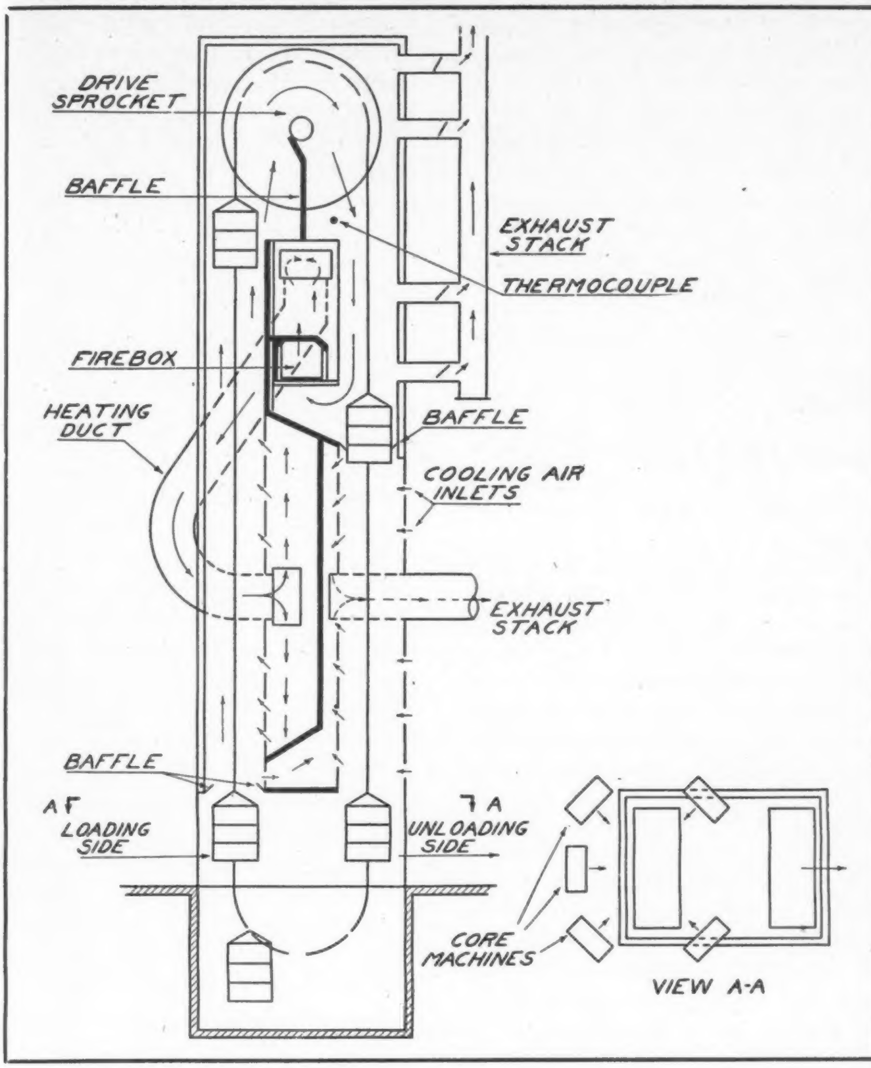


Fig. 20—Cross sectional views of vertical core oven.

of recirculation of gases is similar to that of the other ovens. Firing of the twin burners is regulated automatically by a single oven thermocouple and temperature control instrument. Three-quarters of the space in the oven is devoted to heating and one-quarter to cooling. Air for cooling is pulled into the oven by means of a large fan.

Normal oven control temperature settings (when making the differential carrier and similar size cores) range from 410 to 420° F. Normal cycle time is 4 hrs. (3 hr. heating, 1 hr. cooling). The setting of the timer for this cycle is 6 min. (the conveyor moves twice for each rack, $\frac{2 \times 20 \times 6}{60} = 4$ hr.)

Batch Ovens.—Six batch ovens equipped with recirculation type heaters are in service (Fig. 17). Automatic temperature controls regulate the oven temperature and keep the delivery temperature within safe limits. The principal use of these ovens at present is the baking of extra large cores, or odd lots of cores, not suited to the cycles being run on the horizontal and vertical ovens.

Conclusion

The author has intentionally devoted a major portion of this article to description of this foundry's equipment and to basic controls. It is his personal opinion that in many cases too little consideration is given to the design and control features of coreroom installations. In such instances, it is next to impossible to exercise the basic controls essential to the process, despite use of the most elaborate testing equipment that money can buy. On the other hand, when the installation is good, and it is well operated, a comparatively few well chosen control procedures are sufficient to maintain a high standard of control.

Foundry of the Future

(Continued from Page 23)

enrich our great nation still further.

It will pay us to watch developments in the way of "over-capacity" very closely, and herein the future may have many strange developments in store for us.

Perhaps the last thing to touch upon, and yet the one matter which we will meet first, is the future development of the foundry equipment. This would form a topic upon which discussions may be held by the hour. Suffice it to point out two things: the molding machine, and conveyors. Everything else, as well as these, is wrapped up in the policy the foundry will be forced to adopt in the near future.

Conveying System

Specialization means the molding machine with a vengance. Consolidation gives the sinews of war to adapt, adopt, and force their systematic use. The breaking up of restrictions regarding apprentices means more and better men to do the other molding. Conveying systems mean the systematic production of castings, outside of the molding end, at minimum cost. Continuous molding, pouring and, in fact, continuous work in the foundry based upon short hours with good pay, means getting the best efforts of the men, contented men, and a prosperous country.

Naturally, the study of the foundry in all its details will not cease. Standardization, improved work, uniform customs, we might say—the millenium, minus the human end, which we will never fully control or correct; all things which help to make foundrymen reasonably content with their lifework—all this lies in the future for us.

But we must not be idle in the meantime. If long association with the labor end of the foundry, as well as the financial, counts for anything, I feel that we must do our utmost to place within reach of the youngest apprentice the means by which he can receive a good, general education, as also the special one for his trade. We owe this to our nation as well as to the industry that has made our fortunes. I feel that we have nothing to fear from the man who from his youth is looking for-

ward to his own home, his savings account, the education of his children as useful citizens, and his peaceful retirement when old age comes on. This man, the backbone of the nation, has had no difficulty in realizing his ambition heretofore, and will not have it in the future, as consolidations, instead of cutting him out from opportunities, will give him the chance to become a stockholder if he desires and, by reducing the severity of hard times, keep him in steadier employment.

Men of this stamp, I am glad to say, still are the vast majority of the laboring men of today. Let us help them to help themselves by education, and the future of the foundry need give us no concern.

BOARD MEETING
Records Best Association Year

MEETING IN Executive Session at the Annual Board Meeting held at the Stevens Hotel, Chicago, July 26, the National Directors of A.F.A. reviewed operations of the Association during the fiscal year ended June 30, 1946, and charted the year ahead. Actions taken included approval of Financial and Membership Reports, 1946-47 Budget of Income and Expense, reports of various Committees, recommendations on Committee organization, and election of Staff officers for the current year.

President F. J. Walls presided at the morning session, the final meeting of the 1945-46 Board of Directors. On adjournment he turned the gavel over to the incoming President, S. V. Wood, who conducted the first meeting of the 1946-47 Board of Directors in the afternoon.

President Walls Praised

At the morning session the Directors congratulated President Walls on his stewardship, which was signalized by a new all-time membership record of 8,539 on June 30, and a report showing the financial position of A.F.A. to be the best in in history.

The Directors elected Secretary Wm. W. Maloney as Secretary-Treasurer for the fiscal year 1946-47. Announcement was made of the appointment of S. C. Massari as Technical Director, and John P. Mullen as Assistant Treasurer in charge of public relations activities. Messrs. Massari and Mullen joined the National Office Staff in February on a temporary basis, as was announced in the March issue of AMERICAN FOUNDRYMAN, and now become Staff members for the current fiscal year.

Resolutions approved by the Directors at the Annual Board Meeting in July, 1945, were re-established in connection with Secretary Emeritus R. E. Kennedy and retiring Treasurer C. E. Hoyt. The retirement of R. E. Kennedy and his appointment as Secretary Emeritus was announced in the August, 1945, issue of AMERICAN FOUNDRYMAN.

C. E. Hoyt Retires

The retirement of C. E. Hoyt as Treasurer on August 1, 1946, in accordance with his expressed desires over the past several years, will call to the mind of many A.F.A. members that Ed Hoyt has been active in Association activities for over 40 years. The "dean of exhibit managers," he staged the first foundry exhibit in 1906 at the old Armory in Cleveland and has been in charge of or a major factor in every foundry exhibit since that date.

Ed Hoyt's affiliation with the American Foundrymen's Association was a natural one, for he came from a family of foundrymen and for a time operated with his father a foundry at Wayland, Mich. Without a full academic education he taught foundry practice at Michigan State College and later at the former Lewis Institute in Chicago. In 1907 and 1908 Ed Hoyt staged two-day conventions and exhibits at the Institute and as a result of his interest in A.F.A. was one of the signers of the Association's original Articles of Incorporation in 1916.

C. E. Hoyt

His direct identification with A.F.A. as a Staff officer dates back to 1918, when he first was elected Secretary-Treasurer. He served in that capacity until 1937, when he was elected Executive Vice-President and Convention and Exhibit Manager. In 1941, after 23 years as the chief administrative officer of the Association, he relinquished leadership upon the election of C. E. Westover as Executive Vice-President. Ed Hoyt retained, however, at his request, the title of Convention and Exhibit Manager.

In 1943, upon the resignation of Mr. Westover and the election of R. E. Kennedy as Secretary, the title of Convention and Exhibit Manager was vacated and Ed Hoyt became Treasurer, which title he held until his retirement this year.

Industrial Service

It has always been a source of pride to Ed Hoyt that he was instrumental in bringing Bob Kennedy into the Staff ranks of A.F.A. in 1921, and few men have contributed so much to the progress of an entire industry, in the best traditions of "service." During the past 25 years Ed Hoyt and Bob Kennedy have played the major part in building A.F.A. from a membership of 1700 to the present total of over 8500.

The feelings of those who have known Ed Hoyt and who have been associated with him may best be expressed in the following words of Past President H. S. Washburn when he presented the Seaman Gold Medal to Ed Hoyt in 1941:

> "Mr. Hoyt has taught us the meaning of unselfish service. Possessing the highest attributes of a Christian gentleman, he has attracted to himself and to our Association some of the finest men in our Industry. He has had the gift of being able to share his sterling character with his associates and we are the better because of our close contacts with him."

EXOTHERMIC MATERIALS

Exothermic materials in concentrated form, used as riser additions, provide the heat necessary for proper directional solidification in the casting, reducing riser size and increasing yield.

C. G. Lutts
J. P. Hickey
and
Michael Bock II
Boston Naval Shipyard
Boston

SHRINKAGE IN CASTINGS, of all metal types, is the most troublesome defect encountered in present foundry practice. The problem of shrinkage, coupled with the attempt to obtain as high a percentage of yield of good casting to metal melted as possible, has resulted in many of the recent developments in gating and risering technique.

Such devices as blind risers, external chills, insulating sleeves, and liquifiers or pipe eliminators have been used with varying degrees of success. Steel companies use insulating fire brick for "hot tops" and, at times, have gone so far as to attempt to produce heat in the top of ingots by applying an electric arc.

Liquifiers Applied

Use of liquifiers on open risers has been adopted as common practice in most steel foundries. Usually they are of the insulating type or the mildly exothermic type, or a combination of the two. Liquifiers are also used in bronze foundries, but in this application the liquifier generally provides insulation against loss of heat rather than lowering the freezing point of the metal through absorption of carbon, as is the case with steel. Many foundries also employ dry floor sand to minimize loss of heat.

Usage of new types of exothermic materials in concentrated form for addition to risers, thus providing great heat at the proper place for producing directional solidification, are dealt with in the present paper. Results of tests are given for steel, monel metal and corrosion-resistant steel. As one of the products of these exothermic materials is metal, the composition must match the metal of the casting.

In exothermic reactions the properly sized powders of oxides of metals react with sized aluminum powder to produce the desired metal or alloy, aluminum oxide and heat. The chemical formulas for three general reactions, i.e., for steel, monel metal, and bronze applications, would involve some or combinations of the following:

$$3Fe_3O_4 + 8Al = 4Al_2O_3 + 9Fe + \text{Heat}$$
$$3NiO + 2Al = Al_2O_3 + 3Ni + \text{Heat}$$
$$3CuO + 2Al = Al_2O_3 + 3Cu + \text{Heat}$$
$$Cr_2O_3 + 2Al = Al_2O_3 + 2Cr + \text{Heat}$$

This type of reaction provides the two basic anti-shrinkage aids; production of superheated metal in the riser where heat is needed, and production of a refractory insulating cap in the riser to conserve this heat.

Certain previous experimental work at the Boston Naval Shipyard in making castings entirely of exothermic materials had shown that a small steel bushing could be produced without apparent shrinkage. The casting was made by filling the mold with exothermic powder mixture and igniting the charge in the mold. The surface of the charge was ignited and the reaction proceeded downward through the charge with clean separation of metal and slag.

Figure 1 shows this casting sectioned after removal of the slag layer. It appears that the hot refractory insulating slag on top plus favorable convection currents controlled the cooling rate so that all shrinkage passed out through the top surface without the usual piping effect.

Insulating Slag

The foregoing experiment indicated the desirability of superheated metal plus insulating slag in the riser portions of the mold such as might be obtained by exothermic reactions. This suggested that the mold be filled with ordinary furnace metal to the bottom of the riser, followed by a charge of exothermic mixture to fill the riser. Great heat would be produced at the critical point and the method would be applicable not only to steel but, if proper exothermic mixtures were available, to bronze, monel metal, and any other metal or alloy subject to injurious shrinkage.

However, it was anticipated that the beneficial heat effect accompanying the exothermic reaction might not be so all inclusive as to guarantee solidarity through long feeding paths to points at relatively great distances from the riser. To test this point some of the original experiments were performed on round billets of varying diameter and length.

All of these billets were 20 in. long but divided into groups having diameters of 7, 5 and 3 in., respectively. The slenderness ratio was thus varied, in the case of the last

Presented at a Brass and Bronze Session of the Fiftieth Annual Meeting, American Foundrymen's Association, at Cleveland, May 8, 1946. The opinions expressed in the paper are those of the authors and do not necessarily reflect the views of the Navy Department.

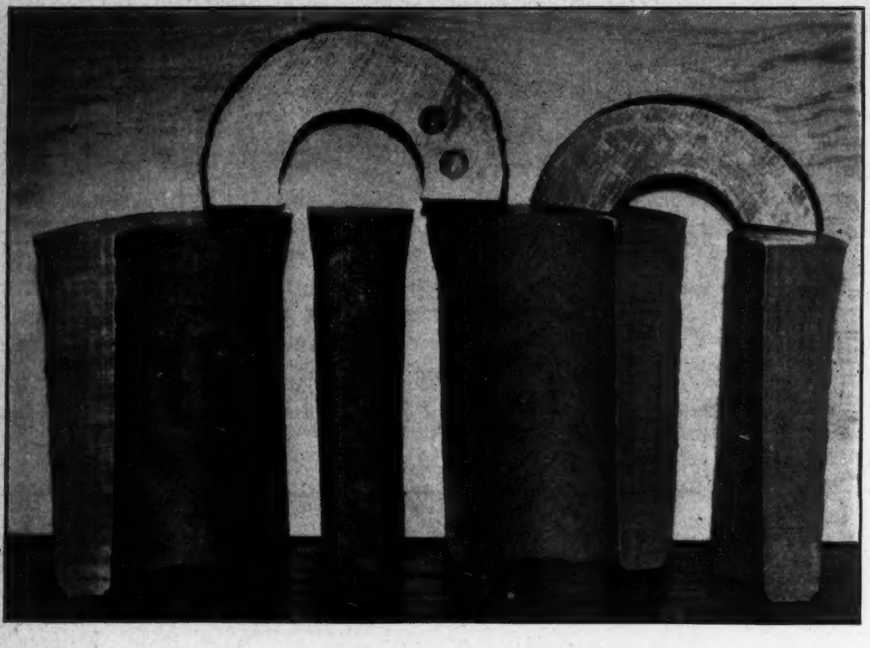


Fig. 1—Steel bushing melted by exothermic process. Slag left on top for insulation to promote feeding. Note that bushing is completely solid.

group the relation was almost 7 to 1, and this was to prove an exacting test. With regard to metal soundness the experiments were not entirely successful as the castings contained some amounts of secondary shrinkage.

However, when the proper amount of exothermic material was added to the risers, approximately 15 per cent by weight, all of the primary shrinkage disappeared. The limitation of feeding a casting from a riser was emphasized by this test. With such a condition directional solidification cannot be readily set up, even with exothermic treatment, and a design change is in order. Up to this point exothermic powders such as described herein serve a most useful purpose.

It is possible to stop pouring a mold when the metal just reaches into the riser and thereby obtain a high yield when the exothermic powder adds a layer of superheated metal at this point. An example of this higher yield is shown in the accompanying table. Both castings were found radiographically sound.

Powders of the exothermic type must be compounded chemically to match the metal to which they are to be added. A mixture of iron oxide with aluminum properly graded as to particle sizes and toned down to the proper heat level is satisfactory for steel, but would not, of course, be suitable for corrosion-resisting steel or non-ferrous metals.

For corrosion-resisting steel the metal generated from the reaction of the liquifier must, in most cases, contain substantial percentages of chromium and nickel. The oxides of chromium and nickel are accordingly incorporated in the original mixture in proper balance with the iron oxide.

In the case of monel metal the mixture is made up of nickel oxide, copper oxide, aluminum powder and other ingredients to control the heat level and the viscosity of the slag. A word of caution is desirable at this point as to the explosive character of copper oxide when inadvisedly used alone or in certain combinations with other oxides, particularly aluminum not properly graded.

This situation makes the produc-

Yield Data for Cam Castings

Casting Weight with Carbon-Type Liquifiers, lb.	
With gate and riser	117
With gate and riser removed	58
Yield, per cent	49.5
Casting Weight with Exothermic Material in Riser, lb.	
With gate and riser	67
With gate and riser removed	58
Yield, per cent	86.5

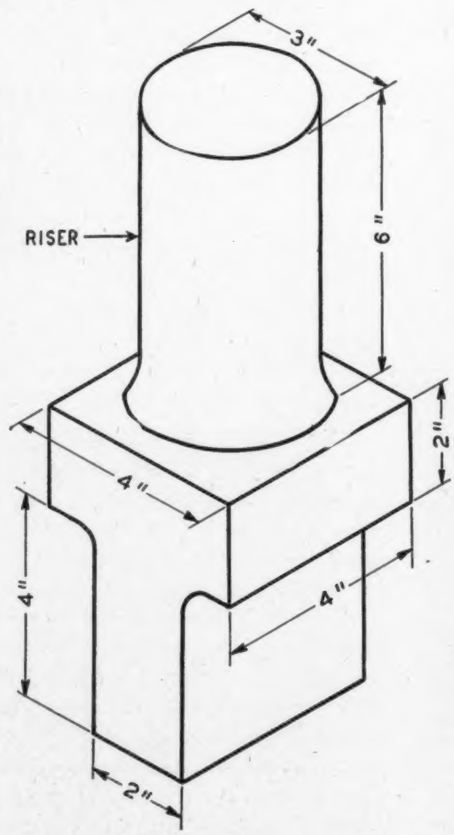


Fig. 2—Diagrammatic sketch of keel block test casting showing dimensions.

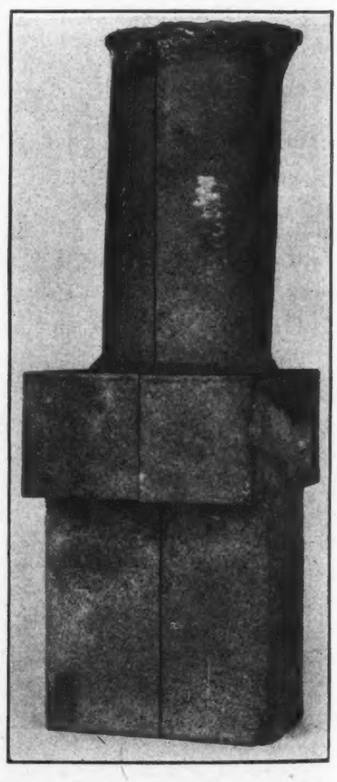


Fig. 3—Keel block test casting with riser. Note line showing where castings were later sectioned.

tion of exothermic powders for copper bronze rather more difficult than is the case with monel metal or steel. However, such exothermic mixtures have been made and can be safely used, with due precautions. No particular problem exists with ordinary steel, nickel-copper (monel) and chromium-nickel mixtures.

Experiments dealing with steel, 20-10 corrosion-resisting steel, and nickel-copper (monel) alloy, are described in the following paragraphs.

Figures 2 and 3 illustrate in half size the pattern and the casting employed in the test. This design of casting has been used recently in other investigations, particularly in the bronze field, to demonstrate the efficacy of gypsum insulating sleeves*.

Ten molds were made, three each for pouring medium steel and corrosion-resisting steel, and four for monel metal. In each case the gate was cut into the back at the base of the riser since in pouring directly down the riser it would have been difficult to stop pouring at the desired level in the riser.

Three castings were poured in medium steel at the same time and from one pot of metal (Figs. 4, 5, 6). One casting (Fig. 4) was poured to the top of the riser and was then covered with an ordinary carbon-type liquifier, following normal foundry practice.

*H. F. Taylor and W. C. Wick, "Insulating Pads and Riser Sleeves for Bronze Castings," AMERICAN FOUNDRYMAN, March, 1946, pp. 48-68.

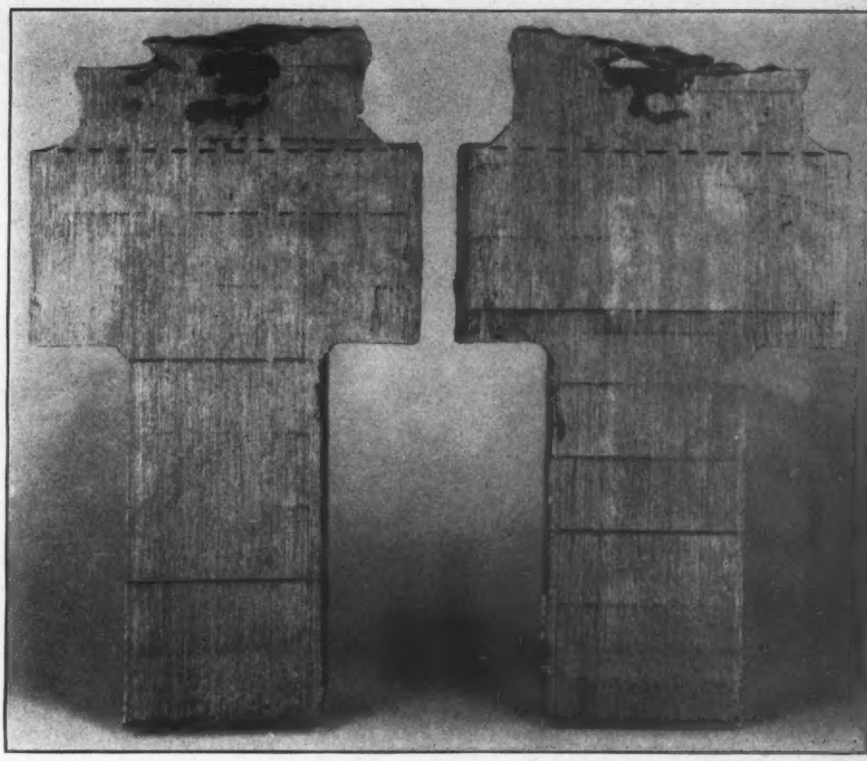


Fig. 6—Class B steel test casting; 2½ lb. steel exothermic powder used; 80 per cent yield of good casting. In this test pouring stopped at bottom of riser near dotted line shown.

Note that the shrinkage extends the complete length of the riser and into the casting. The second casting (Fig. 5) was poured almost to the top of the riser, the same as in the first casting, and 1½ lb. of exothermic powder added in the riser. This addition amounted to approximately 6 per cent of the weight of the casting and risers combined. The shrinkage then was concentrated at the top of the riser.

For the third casting, Fig. 6, the riser was poured short and 2½ lb. of exothermic material was added. Note that the casting itself is sound. The yield of the casting shown in Fig. 6 is 80 per cent, as compared with a yield of 50 per cent for the castings shown in Figs. 4 and 5. The percentage of exothermic addition in this case was 18 per cent.

Corrosion-Resisting Steel

Similar castings were then poured with 20-10 corrosion-resisting steel. The results were the same. The first casting disclosed a deep, dangerous shrink, while the second and third castings were progressively better. Photographs for this test are not included, the appearance of the castings being almost identical with the photographs shown herein for monel metal castings.

Figures 7, 8, 9 and 10 show the nickel-copper (monel) alloy castings. The first casting, without the benefit of exothermic treatment, developed the deep shrink naturally associated with monel metal, in this case suffi-

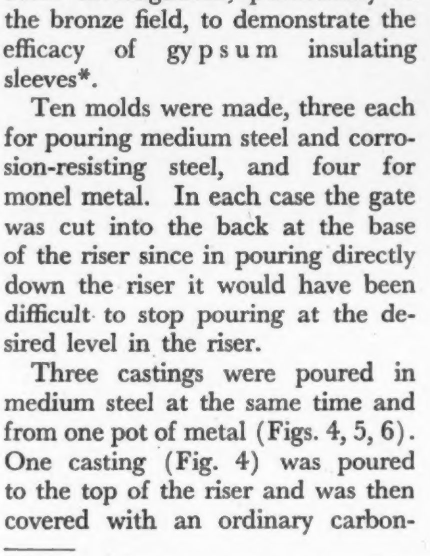


Fig. 4—Test casting of Class B steel; carbon type pipe eliminator used. Shrinkage extends into casting. Weight of riser and casting, 28 lb.

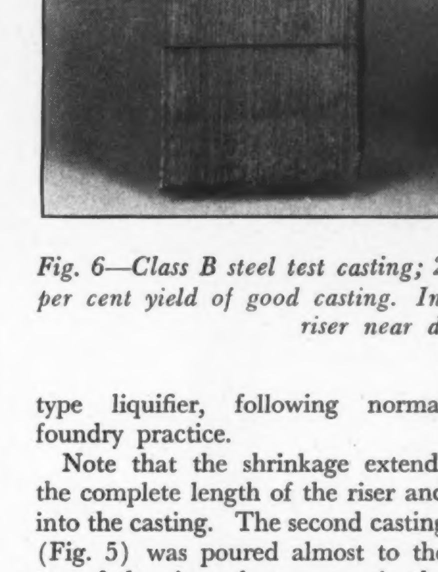


Fig. 5—Test casting of Class B steel; 1½ lb. of steel exothermic powder used in riser. Note lessened shrinkage in top of riser.

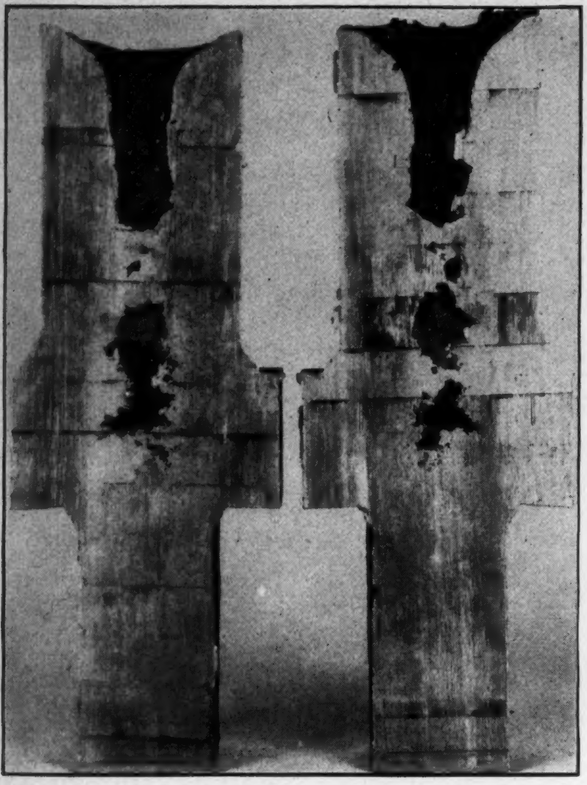


Fig. 7—Nickel-copper alloy (monel metal) test casting; conventional carbon-free pipe eliminator used. Note that shrinkage extends into casting.

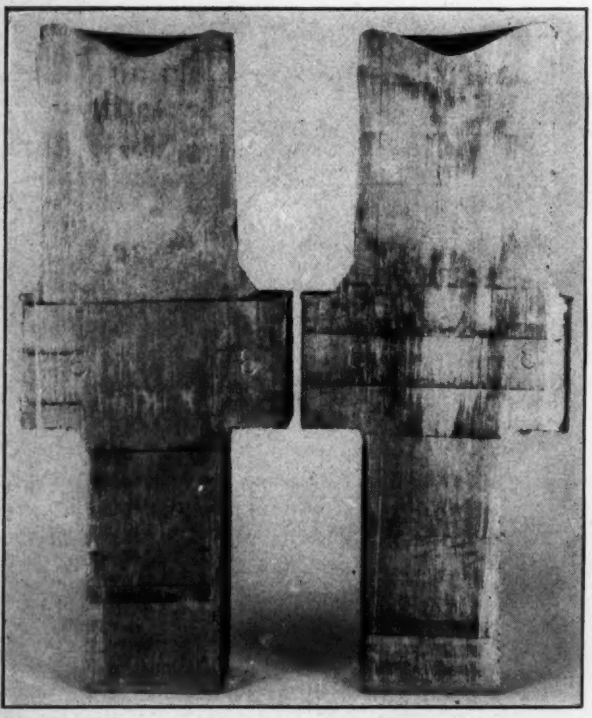


Fig. 9—Nickel-copper alloy (monel metal) test casting; 2½ lb. exothermic material in riser. Note that both casting and riser are solid.

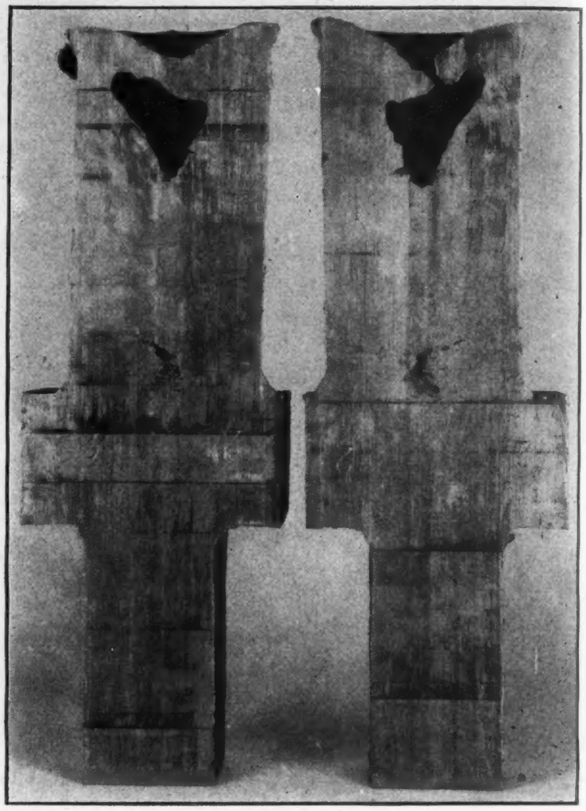


Fig. 8—Test casting of nickel-copper alloy (monel metal); 1½ lb. exothermic material in riser. Casting is sound, although secondary shrinkage is shown at base of riser.

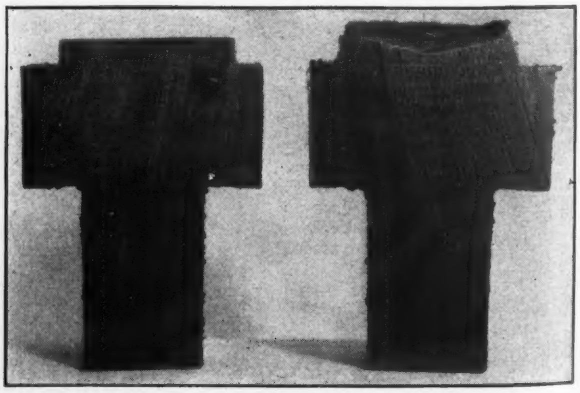


Fig. 10—Test casting of nickel-copper alloy (monel metal); 2½ lb. exothermic material in riser. Note that solid casting has been produced with extremely shallow riser.

Fig. 11—Refractory slag "hot top" produced as a result of exothermic reaction.

Fig. 12—Nickel-copper alloy propeller casting with riser. Casting is gated in center of hub at bottom. Casting and riser weight, 450 lb.

cient to destroy the usefulness of the casting, as illustrated in Fig. 7.

After treatment with 1½ lb. of exothermic material the casting is much improved, but an area of slight secondary shrink persists deep in the riser. Figure 9 illustrates the perfection attained with the 2½-lb. addition. It was decided at this point to try a casting with a minimum of riser, pouring the mold only to the bottom of the riser and then adding exothermic powder.

Figure 10 shows the result—a perfect casting without shrinkage and practically without riser. In the case of these two latter tests particular attention should be paid to the appearance of the riser surface, which suggests that during cooling the level of the molten metal fell uniformly across the riser diameter with little if any inward side freezing. Directional solidification from drag to cope to riser is thus indicated.

Same Composition

A different type of exothermic powder was used for each of the three alloys, i.e., steel, corrosion-resisting steel, and monel metal, so that the hot metal produced exothermically matched the metal of the casting.

In these experiments the exothermic reaction was self-starting from the heat present in the riser metal, and the superheated metal was produced at a temperature of 1000 to 1500° F. above the usual pouring temperature for the metal.

Refractory insulating "hot top" material is practically pure Al_2O_3. The material, as it solidifies, usually contains a number of air layers of various sizes interspersed throughout the slag, or one large cap on the

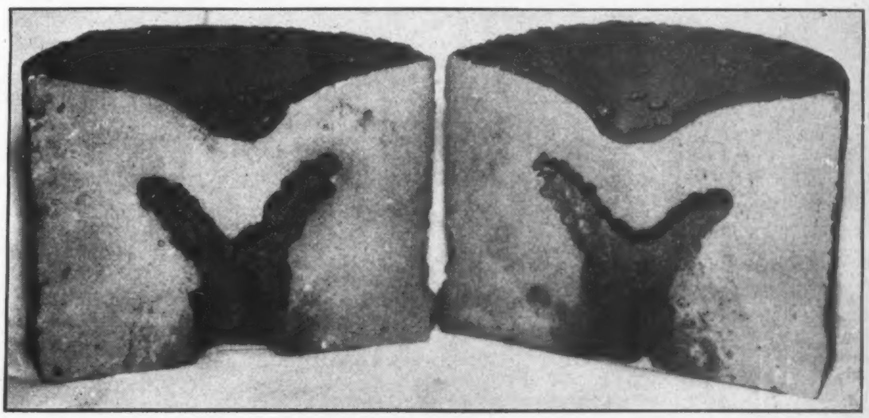


Fig. 13—Sectioned riser from propeller casting showing amount of shrinkage when conventional carbon-free liquidizer is used. Riser, 9½-in. diameter.

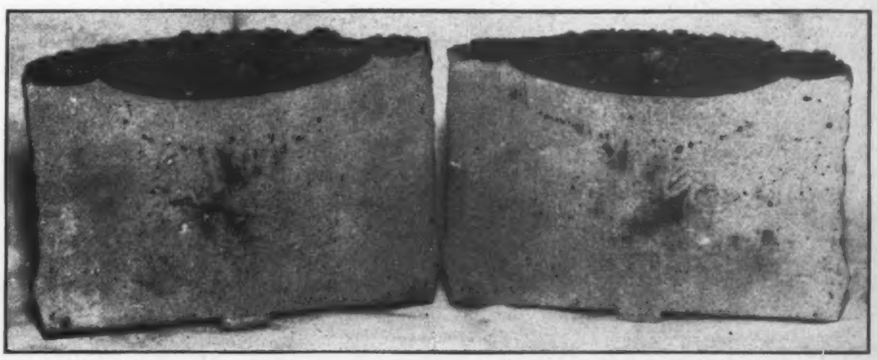


Fig. 14—Sectioned riser from propeller casting; 25 lb. nickel-copper exothermic material used on riser. Note slight amount of shrinkage.

riser. For best results a slag layer over 2 in. thick is desired, although in many instances $1\frac{1}{2}$ in. may be quite satisfactory. Figure 11 shows a sectioned piece of refractory "hot top."

In applying exothermic powders, the success of the operation depends upon using a sufficient amount. In experimental work conducted to date, additions have ranged from 5 to 25 per cent of the weight of the casting and risers combined, the normal amount being about 15 per cent. It appears that the amount of exothermic material will be about the same for all risers of the same diameter.

It is thought in this connection that charts can be prepared showing riser size versus amount of exothermic material. From preliminary work, this method of calculating agrees closely with the percentage basis aforementioned.

The suggestion that exothermic material be used as an anti-piping compound is not new in the case of steel, but is believed to be new in the case of non-ferrous alloys. In the case of steel, recommendations in the literature of some years past as to additions to be made now appear to have been inadequate. For this reason, a practical development and general adoption of the use of exothermic material may have been delayed.

Shrinkage Reduced

Application of exothermic powder to a nickel-copper (monel) alloy production casting is presented as an additional example (Figs. 12 to 14). Figure 12 shows a propeller casting weighing about 270 lb., with a 9-in. diameter riser attached. This was poured by the two methods, first using good normal practice employing the usual protective liquifier, and then with nickel-copper exothermic powder in the riser. The difference in amount of shrinkage can be readily noted from the photographs of the sectioned risers, Figs. 13 and 14.

Figure 13 shows that the shrink defect was 2 in. in diameter and extended deep into the casting. In the case of the casting shown in Fig. 14 the shrink has almost disappeared, but not entirely. The slight shrink may be attributed to the somewhat "skimpy" use of only 8 per cent by weight of the exothermic powder. This test, therefore, again suggests the desirability of using adequate additions.

Conclusions

1. A new method has been demonstrated for making certain types of castings sound and free from shrinkage by applying large amounts of exothermic powders in risers.
2. Exothermic additions to risers beyond those formerly used have produced these results by guaranteeing casting directional solidification.
3. The key to exothermic treatment for castings lies in sufficiency and in the knowledge that there is a minimum percentage quantity necessary to do the job.
4. Cost features have not been considered in this article; these would vary on individual applications and would be influenced by increased yield, cost of the treatment, the necessity for quality, and many other factors.

Found New Center for Metal Process Research

ESTABLISHMENT OF a laboratory of mechanical metallurgy under supervision of Dr. John Wulff, promoted to the rank of professor, has been announced by Dr. Karl T. Compton, president, Massachusetts Institute of Technology, Cambridge.

In announcing the new center, Dr. Compton stated that "requirements of the government service during the war . . . demonstrated the need for a fundamental re-examination of material processing techniques . . ." Advanced courses in process metallurgy, as well as undergraduate instruction, will be offered under the new program.

Also annouuced was the appointment as associate professor of mechanical metallurgy of H. F. Taylor, research associate at the institute since November, 1945, and recipient of the Peter L. Simpson Gold Medal at the recent Golden Jubilee Convention of A.F.A.

Laboratory Direction

Administration of the new laboratory will be handled by the department of metallurgy; and present facilities developed by the department of mechanical engineering will be taken over by the center.

In direction of the laboratory Professor Wulff will have the counsel of an interdepartmental committee composed of Professor C. R. Soderberg, department of mechanical engineering, and Professor John Chipman, head of the department of metallurgy; and will include on his staff Professors F. R. Evans and E. L. Bartholomew, and M. S. Burton.

Professor Wulff joined the staff of M.I.T. in 1931 as an instructor, and until his new appointment was associate professor of metallurgy. He was awarded the degree of engineer of mines from the Colorado School of Mines, Golden, Colo., in 1924; the degree of master of science in metallurgy from Yale University, New Haven, Conn., in 1926; and the degree of doctor science in physics from the University of Tuebingen, Germany, in 1929. From 1925-1926, he was a Sterling teaching fellow at Yale, and from 1929-1931 a National Research Fellow at the Universities of Tuebingen and Munich.

Professor Taylor is well known to the castings industry for his outstanding work in the field and his prominent activities on many A.F.A. national committees within the Foundry Sand Research Project and other groups. He holds a bachelor of science degree in chemical engineering and a master of science degree in metallurgy from Michigan State College, East Lansing.

Foreign Founders Keep Pace with Development

AUSTRALIAN FOUNDRYMEN are well versed in all the latest foundry techniques, according to information reaching the National Office from H. G. McMurry, General Motors Overseas Div., General Motors Corp., Melbourne, formerly Chairman, Saginaw Valley A.F.A. chapter, and active in A.F.A. Refractories Committee and Foundry Sand Research Project.

"I have thoroughly enjoyed visiting foundries and foundrymen in this land 'down under'," writes Mr. McMurry, "and I would like to tell you there are some very excellent foundrymen in Australia . . .

"All the foundrymen I have met read very religiously every foundry periodical published in the States, as well as in England, and are well versed in foundry techniques."

FOUNDRYMEN SURVEY VOCATIONAL SCHOOL FACILITIES

ATTACKING THE PROBLEM of training several hundred skilled foundrymen to meet the requirements of the industry in the Baltimore area, the Chesapeake chapter recently aided in a survey of educational facilities conducted by the Baltimore Association of Commerce.

The Baltimore committee which included A.F.A. National Director E. W. Horlebein, president of Gibson & Kirk Co., Baltimore, made the survey, using a questionnaire civic organizations and A.F.A. chapters in other areas will find useful. Previously printed in the March issue of AMERICAN FOUNDRYMAN*, the questionnaire is given below, with excerpts from the committee report.

Chapter Leaders Polled

Also included are comments by the delegates to the A.F.A. Chapter Chairman Conference, held July 24 and 25 at the Stevens Hotel. These comments were in response to an informal survey conducted during the conference and based on the questions used by the Baltimore Association of Commerce.

Chapter educational committees should note that adequate vocational training is a community problem. Basic to all industry, a healthy foundry industry is essential to a prosperous and progressive industrial community. In studying the needs of the foundry industry with the idea of assisting local educational institutions, educational committees should enlist the services of civic groups, and cooperate with these groups as much as possible. Civic groups and educational institutions welcome such cooperation and are glad of the opportunity to learn more about an important industry with which they are generally unfamiliar.

Schools Receptive

All educational institutions are attentive to the requests of the industries they serve and are willing to establish training courses if there is sufficient demand. Since there is a minimum size of class which can economically be taught, schools want to know the number of students expected to be trained each year.

To question number one of the Baltimore Association of Commerce survey, "What are the probable employment needs of your industry during the next five years?" the foundries of the area replied: "About 250 skilled mechanics and a like number for related work should enter the foundry industry during the next five years.

"Although Baltimore foundries necessarily used semi-skilled workers during the war period, many of these workers have shown little promise as skilled molders or coremakers. It is expected that skilled foundrymen will return from the armed services to help fill the needs of foundries now operating at about 50 per cent of capacity because of the manpower shortage."

Chapter chairmen and other delegates were not prepared to quote figures on local shortages of skilled foundrymen, but all agreed that the problem of training exists. That nearly every A.F.A. chapter has considered seriously the need for training skilled men illustrates the acuteness of the situation.

Typical of the comments regarding training are those of T. H. Benners, Jr., T. H. Benners and Company, Birmingham, Ala., and Chairman of the Birmingham District chapter. Said Benners, "We are going to follow the A.F.A. National Educational Program very closely in renewing our educational activities which were interrupted by the war. We expect to aid the schools in setting up courses and selecting equipment, and plan to invite teachers and students to our chapter meetings. The schools will be offered the services of metallurgists, chemists and other foundrymen for special lectures and demonstrations."

Employment Outlook

The second question in the Baltimore survey asked for an estimate of the present employment total and the postwar prospects for foundry employment. It is estimated that there are approximately 2,000 workers in the foundry industry in Baltimore, one-third of whom are highly skilled mechanics. An annual replacement of five to ten per cent is assumed to be necessary by Baltimore foundrymen.

Postwar prospects for employment in the foundries of Baltimore are essentially the same as exist in other parts of the country. The outlook for employment in the foundry industry, according to the U. S. Department of Labor, is very good for the two-year period 1946-47, and better than in 1945. After a number of years of high employment, a moderate de-

*Vol. 9, No. 3, page 45, "Vocational Schools Train Future Foundrymen."

cline is expected, but employment is expected to remain far above the 1939 level.

Another indication of the good occupational outlook in the foundry industry is based on the opinions of experienced employment counsellors. They say the future is good in an industry requiring training. Most foundry positions are acquired and successfully held by trained men.

Baltimore foundrymen were asked to express an opinion of the training job being done by the local schools, basing their answer on boys and girls employed in the past.

Lack Background

The committee reported that boys entering the foundry industry in the past had only a very elementary education and had no vocational education of any kind. Lack of foundry training has resulted in a large turnover in employees in the Baltimore area.

The answer to another part of the questionnaire is a natural result of this lack of training. The Baltimore committee definitely urged, and some members insisted, on the establishment of a foundry course. This was in answer to question nine: "What new types of courses would you suggest the schools offer?"

The foundry industry in other localities is also suffering from lack of vocational training for interested young men. As in Baltimore, A.F.A. chapters are studying the problem and cooperating with schools. Earl Strick, finishing superintendent, Erie Malleable Iron Company, and Chairman of the Northwestern Pennsylvania chapter, stated: "The Erie foundry show [reported on page 43 in this issue of AMERICAN FOUNDRYMAN] has enhanced the possibility of getting foundry courses installed in Erie schools. As a result of the show, we had the biggest influx of high school students into the foundry industry in the history of Erie."

Long famed for outstanding vocational training in foundry practice and patternmaking, the Cleveland educational system will have a new vocational school as a result of a recent favorable vote on a municipal bond issue. The Northeastern Ohio chapter was very active in promoting interest in the new school and was especially instrumental in obtaining passage of the issue, according to Chapter Chairman Henry J. Trenkamp, president of Ohio Foundry Company, Cleveland.

The youngest A.F.A. chapter is actively aiding Peoria to obtain a new vocational school to replace present inadequate facilities. The new vocational school will offer training in all trades and is expected to meet the needs of the smaller foundries unable to put on their own training programs, according to Zig Madacey, Chairman of the Central Illinois chapter and foundry superintendent, Caterpillar Tractor Company, East Peoria. Also present at the conference of chapter chairmen, Carl W. Wade, Secretary-Treasurer of the baby chapter, Chairman of the A.F.A. Apprentice Training Committee and training supervisor in the foundry division of Caterpillar Tractor Co., said: "Training in foundry practice and patternmaking will be an important part of the curriculum of the new school."

In answer to the fourth question, which requested an opinion of the equipment and technical processes used by the schools in trade training for the foundry industry, the Baltimore committee reported: "Except for related subjects, equipment and facilities for vocational training in the foundry industry in Baltimore are, for all practical purposes, nonexistent."

Many A.F.A. chapters have assisted vocational schools in selecting and securing foundry equipment and in shop layout. Laid out with the assistance of the Twin City chapter's educational committee, the new metals shop in Central High School, Minneapolis, will be fitted with equipment secured from a former National Youth Administration training foundry.

Training Approach

Opinions of teaching methods, item five of the Baltimore questionnaire, had to be based on handling of subjects other than foundry practice because of the absence of facilities for foundry training. The investigating committee felt that the approach to teaching a trade was not as practical as it could be, and that shop habits could be emphasized to a greater extent. Regarding this, National Director E. W. Horlebein said: "There seems to be too great a step from the school to actual industrial work. This may be broken down to a great extent by having part-time work under actual shop conditions as a separate section of the course."

The answer to question six is closely related to question five, and was made on the basis of observations made of teachers in subjects other than foundry practice. Question six called for an expression of opinion of the teaching staff. The committee had no criticism of the teaching ability of the instructors, although it felt the instructors were too educational minded and not sufficiently practical.

This is not an uncommon criticism from industrial men. Most educators believe in teaching skill and precision first, and letting speed and high production come after the worker learns shortcuts which may safely be taken without depreciating quality.

Teaching Staffs

Confidence in the ability of teaching staffs was expressed by all delegates to the Chapter Chairman Conference. This is the result of close cooperation between the chapter and the local vocational school. J. P. Lentz, Chairman of the Central Indiana chapter and foundry metallurgist for International Harvester Co., Indianapolis, said of Indianapolis' Arsenal Technical High School: "The school is doing an excellent job and the foundry industry is well satisfied. No criticism of the instructors of the courses can be offered."

Speaking of Washburne Trade School in Chicago, L. H. Hahn, Chicago Chapter Chairman and metallurgist, Sivyer Steel Castings Co., said: "We are well satisfied with the teaching staff. However, a better foundry laboratory and more instructors are needed to handle large classes and many GI trainees."

"Aside from the vocational type of training given in the schools, do you think the instruction given in mathematics, English and other general subjects is adequate?" was the seventh question.

Greater emphasis could be placed on mathematics and English, the committee reported, and suggested that students should be encouraged to start their own library of books pertaining to the work they are pursuing. Textbooks showing specific applications of the related training to the trade were suggested.

Proper balance, of course, was the subject of the eighth question: "In

preparing young people for your industry, would you prefer that the schools put more emphasis on general academic subjects, more on shop type training, or more on related classroom subjects of a vocational nature?"

It was the opinion of the Baltimore committee that more emphasis should be placed on subjects of a vocational nature, especially shop mathematics, mechanical drawing, blueprint reading, etc. It was felt that a sufficient acquaintance with general academic subjects should have been gained by the student before entering the vocational courses.

Dealing with a type of education becoming increasingly important, question ten was concerned with vocational-technical training.

Definite interest in vocational-technical training was evidenced by the committee. It suggested that such students could be used as engineering assistants, and for development as foremen and supervisors, inspectors and sales engineers.

Need for this type of personnel was brought out in a recent report by the Committee on Relations with Industry of the American Society for Engineering Education (formerly S. P. E. E.). Estimate of this committee show that the proportion of technical institute graduates needed today is twice as great as in the early 1930's. The type of vocational-technical education required is available in some advanced vocational schools and an increasing number of technical colleges.

Interest in vocational-technical training, stemming from the current shortage of skilled men including those capable of assuming supervisory positions, is shown in the following tabulation, based on the Baltimore report. Question eleven called for an indication of the number or proportion of individuals with various types of training which the Baltimore foundries might absorb directly from the schools.

Type of Education	*Pct. of New Employees*
Elementary school but no trade training	None
Elementary school with some shop type training	20
High school with incidental vocational subjects	20
Elementary school plus vocational training in high school years	20
Full high school plus specialized technical training	40

Employment of women in the Baltimore area is expected to fall off, according to the committee. Answering a question regarding future employment and training of women, the committee stated that women will continue to be employed at some jobs in some types of plants. It is believed that replacements will be made with men, however, and a course to prepare women for foundry work is not advocated.

Specific Recommendations

The final item of the questionnaire requested ideas for developing closer contact between industry and the schools.

The committee was in favor of further consideration of these suggestions:

a. Loan of instructors to schools by industry.
b. Loan or gift of equipment and materials.
c. Summer employment in industry for vocational teachers.
d. A systematic program under which school pupils visit industry and observe productive operations in the trade for which they are preparing.
e. A cooperative program under which boys and girls spend alternate periods working in industry and studying in the schools.
f. A school employee to act as liaison officer or coordinator between your industry and the schools.
g. An industry committee to work closely with the schools.

These suggestions, and others, are included in the A.F.A. National Educational Program outlined in the January issue of AMERICAN FOUNDRYMAN.*

Many chapters, through an educational committee, maintain close contact with vocational schools.

"Vocational schools have requested and are receiving the assistance of the Philadelphia chapter in revising foundry courses," said B. A. Miller, Chapter Chairman, and chief metallurgist, Cramp Brass and Iron Foundries, Eddystone, Pa. "Chapter members will be furnished to the schools as lecturers," he said.

"The Cincinnati chapter maintains contact with schools by inviting superintendents, teachers and students to technical meetings," reported Chairman J. S. Schumacher, chief engineer of Hill and Griffith Co., Cincinnati. "So much interest developed last year we are planning four or five special meetings for the benefit of students," he said.

Supply Magazines

The Eastern Canada and Newfoundland chapter carries on an interesting form of cooperation with the Montreal Technical School, according to A. E. Cartwright, metallurgist, Robert Mitchell Co. Ltd., and R. E. Cameron, secretary-treasurer, Webster and Sons, Ltd., chapter Vice-Chairman and Secretary, respectively. After Montreal foundrymen have finished reading AMERICAN FOUNDRYMAN, some of the copies are given to the school. These copies supplement the one received by the school, which holds membership in A.F.A.

West Coast foundrymen are actively cooperating with vocational schools, according to W. D. Emmet, Chairman of the Southern California chapter and foreman, Los Angeles Steel Casting Co. "We have selected foundrymen to act as instructors for the schools which requested such service," he said, "and we are now searching for a suitable text for the schools, as well as for the educational series of lectures sponsored by the chapter."

*Vol. 9, No. 1, page 80, "National Education Program Outlines Objectives."

Erie Foundry Exhibit

(Continued from Page 43)

past chairman, Northwestern Pennsylvania chapter. Other participants in the 15-minute broadcast were E. M. Strick, Erie Malleable Iron Co., Erie, chairman, Northwestern Pennsylvania chapter; H. F. Scobie, educational assistant, A.F.A. National Office, Chicago; E. T. Knobloch, president, Manufacturers Association of Erie, and Dr. C. H. Grose, superintendent, Erie City School District.

The broadcast opened with the reading of a proclamation from C. R. Barber, mayor, City of Erie.

Mr. Griswold expressed appreciation for the sincere cooperation of those assisting with the exhibit, which afforded the youth and citizens of Erie the opportunity to learn that foundries offer steady, interesting and well-paying positions.

Mr. Knobloch pointed out that foundries form a basic industry and therefore bring other industries and manufacturers to Erie.

Expressing great interest in the Erie foundry exhibit as an educational medium, Dr. Grose encouraged all high school boys to attend. He said that the schools stand ready to establish classes in foundry instruction when requested.

H. F. Scobie greeted foundrymen and others of Erieland on behalf of all members of A.F.A. and stated that it was good to see the enthusiasm shown by the Northwestern Pennsylvania chapter in demonstrating that the foundry offers a career to young men.

Mr. Strick summed up the opening of the show, saying that "the foundry is the backbone of all industry, and it is a good place in which to work."

Stress Education

Special features of the show included motion pictures, radio broadcasts, and the several special information desks.

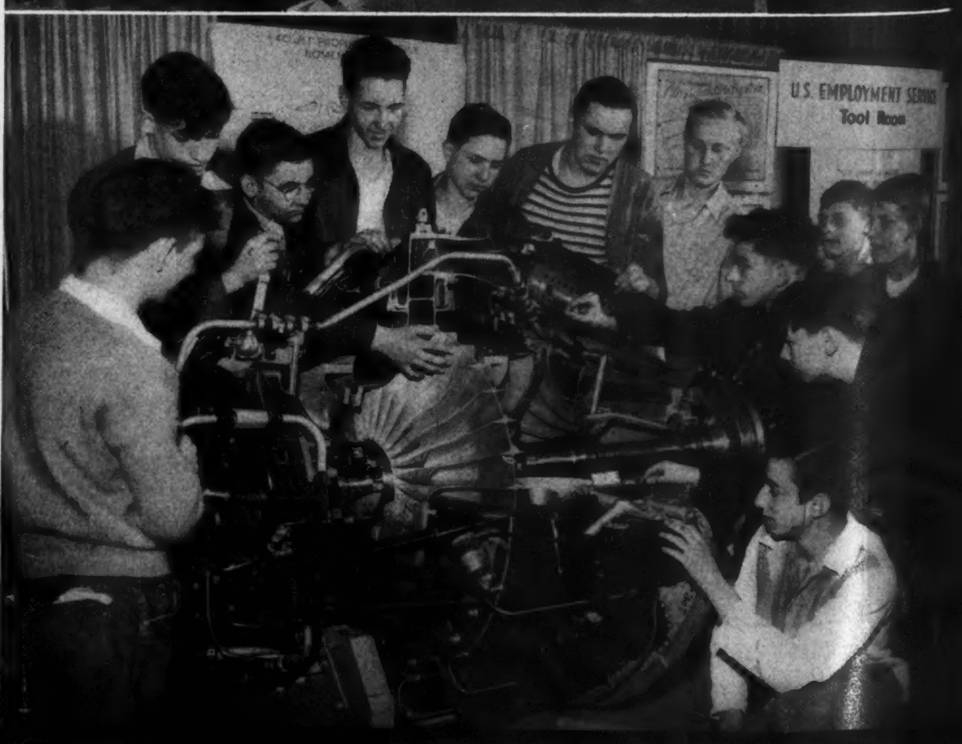
Motion pictures of foundry practices and processes were shown daily at 3:30 and 8:30 pm. The movies were followed by talks on opportunities in the foundry industry, and a drawing for door prizes. These sessions were attended by hundreds of adults and many school children. Special visitations were arranged in cooperation with the schools.

Noon radio broadcasts took listeners on tours through the exhibits giving those unable to attend first-hand information on the production of castings from the blueprint to the finished product. The Friday broadcast honored old timers, some with over 50 years of service in the foundry industry.

An interesting sidelight was the presence, at one of the special information desks, of Boy Scout leaders, who explained qualifications for a merit badge in foundry practice.

Publicity for the show was handled by Todd George and Dave Bole, General Electric Co., Erie, with cooperation of J. P. Mullen, publicity director, A.F.A. National Office.

Students displayed keen interest in the recent foundry exhibit in Erie, Pa., June 5-7. At top, a group of high school boys examine core-making equipment, which many of them were permitted to operate during the show. Bottom, a jet propulsion engine—and castings used in its manufacture—arouse attention.



HEAT TREATING FURNACES

Although specifically directed toward the metallurgist and engineer, the present paper establishes several leads into the more practical field of furnace operation. It is hoped to follow up with a paper dealing with points of operation which will be of particular interest to furnace operators.

Dr. Victor Paschkis
Research Associate
Columbia University
New York

SELECTION OF FURNACE TYPES for the heat treatment of castings—stress relief, annealing, malleableizing, heating for quenching, tempering—is the responsibility of the metallurgist and engineer, to whom this paper is, in the main, addressed.

Furnace Classification. Several ways for convenient classification of heat treating furnaces are available. One refers to the mechanical design of the furnace, another to the source of heat or energy, and a third to the method of heat transfer. These three ways of classification are briefly reviewed in the following paragraphs.

Grouped according to mechanical design, the most commonly used furnace types in foundry work are the following: box type, car bottom type, elevator type, bell type, and continuous furnaces. Among the latter, conveyor furnaces, pusher type furnaces, walking beam furnaces are examples. Figure 1 shows diagrammatic sketches of some of these furnace types.

Presented at a Malleable Foundry Practice Session of the Fiftieth Annual Meeting, American Foundrymen's Association, at Cleveland, May 7, 1946.

Grouping of furnaces for heat treating purposes in foundries may be based on the fuel or energy form applied. However, the fuel or energy form has much less influence on quality of the product than is frequently believed, and the question of best results has to take into consideration many other factors besides the form of energy, factors which are frequently more important.

In the third method of classification, referring to the mode of heat transfer from the heat surface to the charge, three basic types, namely, radiation, convection, and conduction furnaces, can be distinguished. Combinations of the three types are sometimes used. In radiation furnaces, heat transfer from the source to the charge is by radiation only (Fig. 2A). Examples are resistor furnaces and radiant tube gas furnaces. In convection furnaces, heat transfer is carried out by movement of gases or air. The atmosphere is heated by an energy source which in pure convection furnaces is located outside the furnace chamber, as shown in the sketch (Fig. 2B).

Circulation is enforced by blowers or fans. Electric resistors or gas or oil burners can be used as energy source; if gas or oil burners are used it is necessary to bleed part of the circulating atmosphere, but a large part can be recirculated. Conduction furnaces are lead or salt baths, in which the heat is transferred to the charge by conduction alone. Among the salt bath furnaces the electrode salt bath (Fig. 2C) deserves particular mention. In this furnace the salt itself serves as resistor and as heat transfer medium to the charge.

Combinations of radiation and convection furnaces or of radiation and conduction furnaces are used in most cases. Particularly, only rarely are pure radiation or pure convection furnaces applied. In radiation furnaces, the atmosphere of the furnace chamber circulates by natural convection, even if no blowers or fans are used. In convection furnaces, the walls radiate to the surface of the load.

Selection of the correct furnace

Loading white castings into a continuous malleableizing furnace.

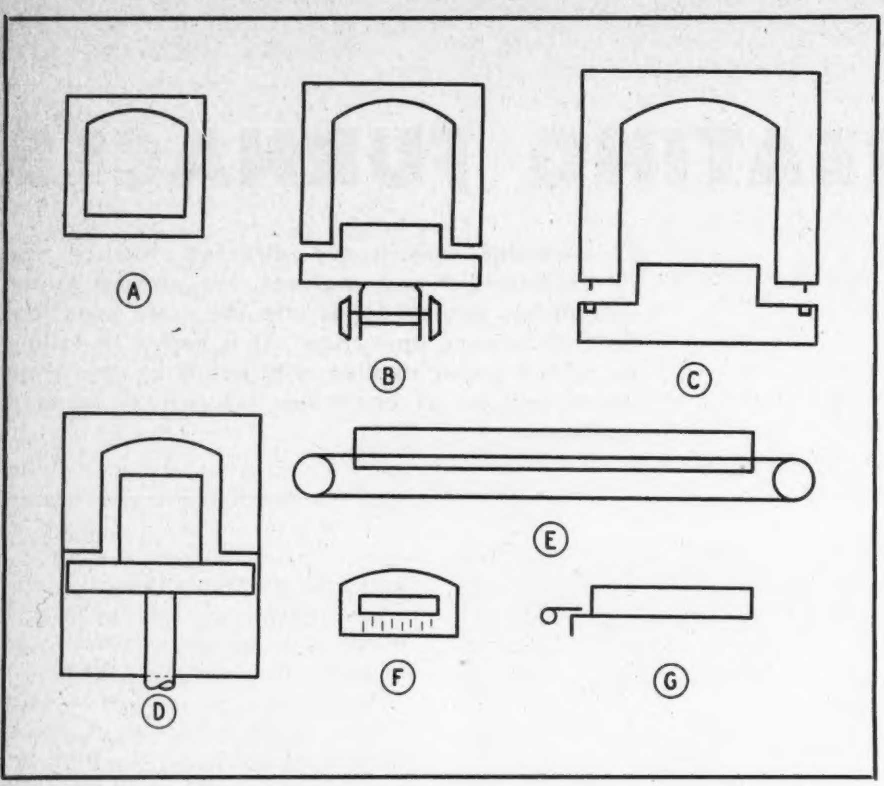


Fig. 1—Diagrammatic sketches of heat-treating furnaces. A—Box type; B—curved bottom; C—bell type; D—elevator type; E—conveyor; F—walking beam; G—pusher type furnace.

type among these various possibilities should take into consideration a number of different problems, some of which are often overlooked. Therefore, the basis for selection will be discussed first. Anticipating the later findings, it may be stated here that, for obtaining highest quality, continuous furnaces would be desirable, but their use offers some difficulty in satisfying the other requirements. Later sections will therefore deal with the problem of how to reconcile the different requirements.

Basis of Furnace Selection. Furnace type selection should take into consideration the following items:

1. Uniformity requirements.
2. Heating and cooling requirements.
3. Individual size, shape, cross-section and weight of the greatest casting to be heat treated.
4. Desired temperature range of work.
5. Desired output of the furnace.
6. Space requirements.
7. First cost, including cost of gas, oil or electric lines from the point of delivery to the plant to the furnace.
8. Operating costs, including cost of energy or fuel, labor, rejections, cost of maintaining fuel reserves.

Uniformity; Heating and Cooling Requirement. In this listing the uniformity and heating and cooling requirements were placed first because they are so frequently overlooked. In order to understand them, it is important to define the terms used.

In furnace work, three types of uniformity must be considered; namely, uniformity in time, uniformity in space, and thermal uniformity in the workpiece. *Uniformity in time* is measured by the temperature recording instrument and demonstrated by its record. However, a high degree of uniformity in time proves only that the temperature within the thermocouple protection tube is constant and does not give any information concerning the uniformity of the workpiece, which is the only uniformity governing the quality of the product.

Temperature uniformity in time is a necessary prerequisite for, but in no way a proof of, thermal or other uniformity of the product. Figure 3 may serve as an example. The almost smooth line (a) is a typical temperature record, showing the temperature inside the thermocouple protection tube. The wave line (b) shows the temperature outside the tube. The thicker the tube, the greater is the relative difference between the two curves.

Furnace Temperatures

Uniformity in space refers to the temperature at various places within the furnace chamber, mostly with reference to the empty chamber. Although this uniformity is important for obtaining thermal uniformity of the workpiece, it is not sufficient for safeguarding it and depends on the way of loading the furnace, not on furnace design alone.

Thermal uniformity of the workpiece includes three requirements which should be fulfilled at all points of the charge; namely, equal temperatures of all points in the piece at the end of the heating or cooling process, equal rates of heating or cooling (degrees per unit time), and equal time at any temperature beyond the room temperature. These requirements can never be fulfilled entirely in practice because heating and cooling can be carried out only under the influence of temperature differences.

At times, in foundry practice, the differences in all three respects are so far from the requirements for uniformity that uniform products are

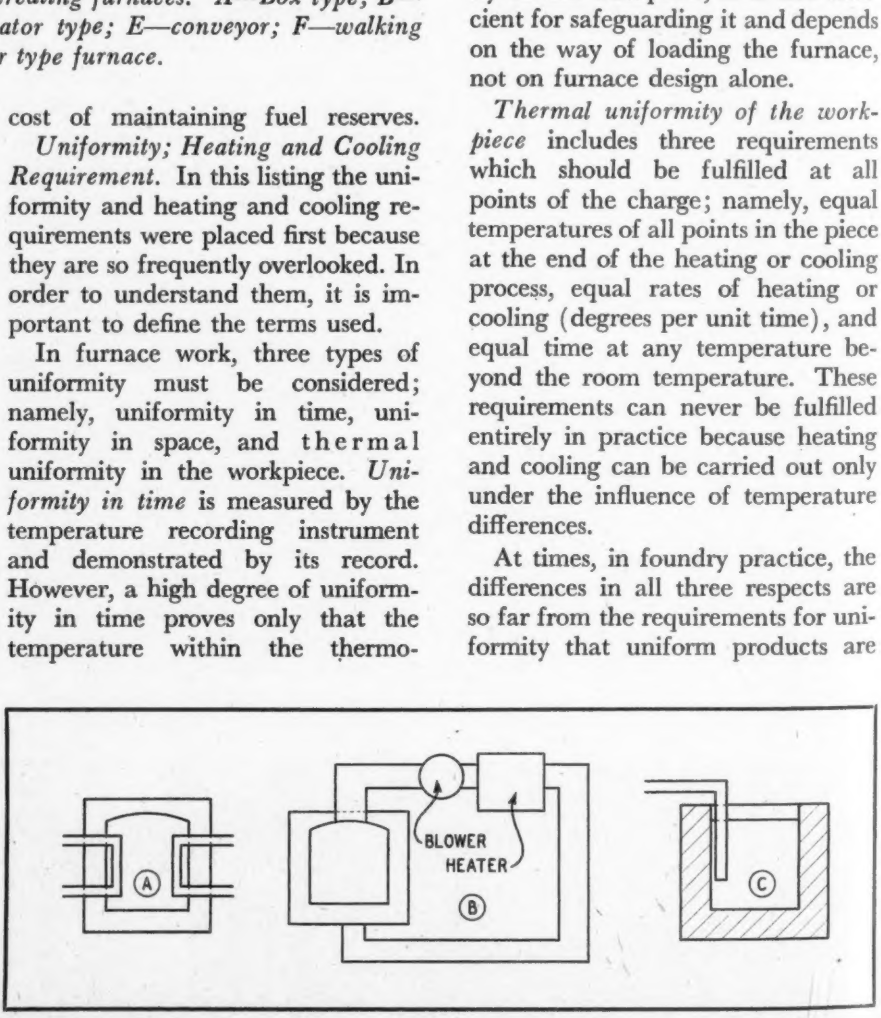


Fig. 2—Furnace types according to heat transfer. A—Radiation type; B—convection type; C—conduction type furnace.

not obtained. The degree to which these requirements are fulfilled depends on furnace design and operation.

It can be proved that the best way of heating and cooling to approach uniformity is to expose each workpiece individually. In heating without individual exposure—for example, when heating piles of castings in radiation type furnaces—the castings located on the outside will be at a high temperature long before the pieces in the center. Moreover, they will heat at a much higher rate than will the castings in the center.

Finally, each casting, if it is of any appreciable size, will heat non-uniformly, the part closest to the heat source heating at a faster rate and to a higher temperature than the part of each casting away from the heat source.

Figure 4 shows schematically the temperature rise in a charge composed of small castings, heated from the side walls of a furnace 4 ft. wide. The furnace walls are assumed to be at a constant temperature of 1600° F. In Fig. 4 time is plotted as abscissa, and temperature as well as rate as ordinates, in logarithmic scale. This kind of scale is, of course, not proportional. The distance from "1" to "2" is larger than the distance from "9" to "10." On the other hand, the distance from "1" to "2" is the same as the distance between "10" and "20."

Heating and cooling requirements comprise the desired temperature of the casting and minimum and maximum rates. It is basically unsound to specify only one temperature for heat treatment because, as explained in the foregoing, complete temperature uniformity can never be achieved in practice. Two final temperatures, one indicating the maximum, the other the minimum permissible temperatures, should be shown in the specifications (for example: "heat to a temperature of between 1550-1600° F.") Based on these temperatures the necessary heating time for a given charge can be calculated with reasonable accuracy.

Assuming that the furnace temperature remains constant during the heating process, only one value of heating time and one furnace temperature will produce a charge in which, at the end of the heating time, the surface has reached the maximum temperature, and the center the minimum temperature. Figure 5 shows the heating curves for surface and center of a large casting of uniform cross section. The difference between the two lines decreases slowly, and the heating time is therefore practically determined by the desired difference at the end of the heating time.

Maximum and minimum temperatures and rates generally are prescribed either on the basis of experience alone or on the basis of laboratory experiments with samples of small size. The values determined for small samples must not be used for heavy castings without change. It is necessary to transform them according to the size and shape of the casting, and with piles of castings, according to the mutual arrangement. Moreover, the mode of heat transfer enters the picture.

It is no longer sufficient to esti-

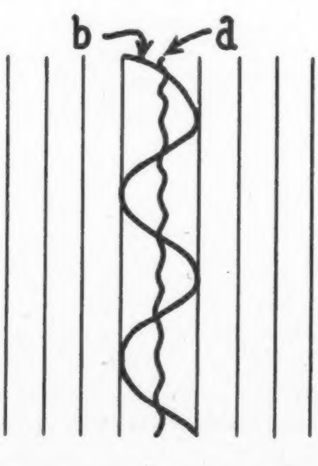


Fig. 3—Typical temperature curve; (a) record within thermocouple well; (b) curve outside the well.

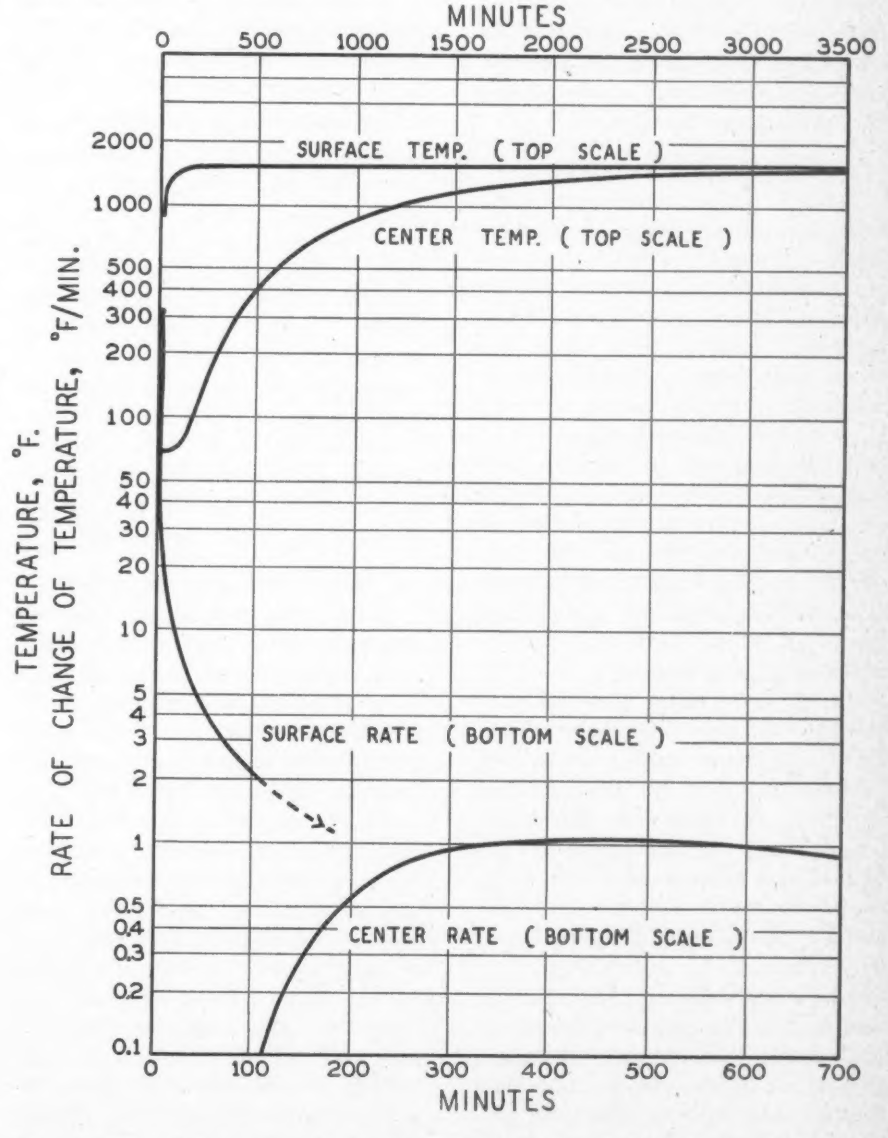


Fig. 4—Temperature rise in charge composed of small castings. In addition to temperature curves, the chart also contains curves for the rate of temperature rise (° F./min.).

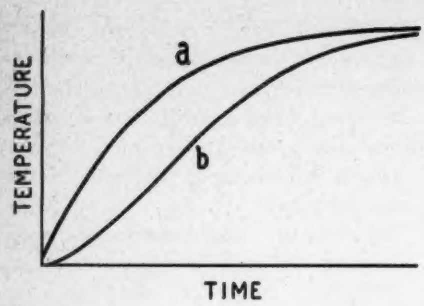


Fig. 5—Typical heating curves for surface (a) and center (b) in heat treatment of large castings.

mate the influence of these factors on necessary heating or cooling time to obtain the desired final temperatures and rates, and it is equally misleading and wrong to assume that the temperatures and rates measured at any one spot within a charge apply to the entire charge equally. Today it is possible rationally to transform the values obtained on samples of small size into values for various arrangements of the charge and various furnace designs.

Heating Rate

Assume that the temperatures and rates have been found acceptable when exposing a cylindrical sample of 0.5-diameter to a furnace temperature of 1800° F. for 3 min. From available charts it can be found that at the end of this period the surface temperature of the sample is 1679° F., and the center temperature is 1675° F. The rate of heating at the surface after 1½ min. is 0.121° F. per sec., and, at the same time, at the center is 0.126° F. per sec.

Also, from existing charts one can now determine that for a rectangular block 4 in. thick, the furnace temperature would have to be 1720° F. in order to obtain the same temperature difference between surface and center at the end of the heating period, and that the heating time would be 138 min. For this condition, the rate of heating after one-half of the heating time (69 min.) would be 0.631° F. per sec. at the surface, and 0.693° F. per sec. at the center.

Maximum Individual Size, Shape and Weight; Output and Space Requirements. In commercial foundries the output in tons per day is subject to daily fluctuations, whereas in production foundries the output can be considered fairly constant over a certain period of time. For the production foundries, no special remarks are necessary. In commercial foundries operations can be made much more satisfactory if the practice of heat treating every casting immediately after cleaning is abandoned. Rather, certain planning of the heat treating is desirable, because operations are more satisfactory if only pieces of the same or almost the same size are heated simultaneously.

Accumulation of castings over several days makes possible the loading of furnaces more nearly as desired. The operation will be more satisfactory the longer the period which can be averaged. For example, if the material is stored up to a maximum of one week, operation will be more satisfactory than if the maximum time of storage is three days. Such grouping of the output, of course, makes it necessary to store part of the output, and this involves problems of rapid delivery and of space requirements.

Castings of one size are often made of steels of different composition, a fact which makes the foregoing recommended practice less desirable. Inasmuch as the composition cannot be recognized from the outside, castings of different composition may become mixed in heat treating. Moreover, with the same theoretical composition, the actual compositions may change slightly from day to day. Consequently, from this point of view, it is desirable that pieces cast on various days be not heat treated in the same furnace operation.

Furnace and Storage Space

Space requirements include the furnace proper and control equipment, as well as possible storage space for production, as mentioned in the preceding paragraph. Floor space generally is larger for continuous furnaces than for batch-type furnaces. A comparison between batch-type and continuous furnaces must, of course, be based on the same output and should be based on the same degree of uniformity and heat.

As previously explained, a degree of uniformity similar although not equal to that in continuous furnaces with individual exposure of each casting can be obtained in batch-type furnaces when heating piles of castings. In the latter case, much longer heating and cooling periods are required than in the continuous furnace. Longer heating times in turn call for larger volume, and this in turn means more floor space. The actual advantage in floor space of the batch-type furnace as compared with the continuous furnace must be attributed to the greater height of the batch-type furnace for equal volume.

Operating Cost. The furnace operating cost should include not only fuel, labor and maintenance, but should take into consideration in some way the quality of the product. If by one method of operation the quality of the product can be increased as compared with other methods, then it is reasonable to introduce into the cost balance calculation an item covering this improvement. This can be done either by lowering the amount for the expense caused by rejections or by introducing an increased amount for the income from a higher quality product.

Cost Comparison

No general statement concerning operating costs of different furnaces is possible. If only the output is taken into consideration without comparing the achieved uniformity, then continuous furnaces are always more expensive than batch-type furnaces. However, if several batch-type furnaces were installed to yield the same uniformity as the continuous furnace, then the first cost of the batch-type furnaces may be larger than that of a continuous furnace of equal output.

Furnace Type Selection. Problem: It has been stated in the foregoing that the requirements of uniformity are best satisfied in furnaces designed for individual exposure of each casting. This requirement must be reconciled with the requirements for space, first cost, and diversity of production. How the three main types

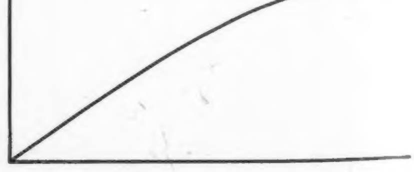


Fig. 6—Example of desired temperature rise of the heating gases in a furnace with progress control.

previously mentioned satisfy these different needs will now be considered.

For piles of small castings, the conduction furnace, although rarely used at present, would be extremely efficient. The salt penetrates rapidly into the spaces between the castings and surrounds each casting quite uniformly. The heating will be rapid and, provided that the castings have the same shape, they will heat uniformly. Although the main advantage of a conduction furnace would be obtained with small castings, it is possible to heat large castings in such furnaces. The large castings are of a reasonably uniform cross section and if rapid heating is permissible, then satisfactory results may be expected.

Rate of Heat Loss

Because of the rapidity of heating in the salt-bath furnace, high output can be obtained. Generally speaking, salt-bath furnaces have a relatively high rate of heat loss because of radiation from the bath surface. No existing cover design entirely overcomes this difficulty. Therefore, the operating costs are quite high if the castings must be held at elevated temperatures for any length of time.

Convection-type furnaces. In such furnaces piles of castings may be heated with reasonable uniformity provided that the flames or the hot air are forced through instead of merely washing the surface of the pile. In such a furnace the castings close to the entrance of the flames or air are heated more rapidly than those near the exit of the heating gases. To overcome this disadvantage and obtain a satisfactory degree of uniformity, the furnace must be equipped with so-called program control. The temperature of the heating gases initially should be low and increase only gradually as the charge picks up heat (Fig. 6). This method of operation results in an acceptable compromise between the desire for high output and good uniformity.

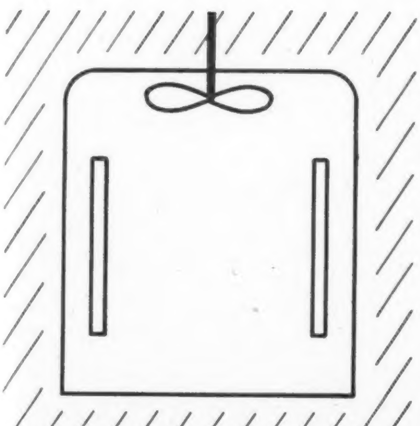


Fig. 7—Sketch of mixed convection radiation furnace.

Temperature limits of such furnaces are in the order of magnitude of 1700° F. It should be understood that reference is made to pure convection furnaces, and that the advantages claimed do not apply to radiation furnaces in which fans are used to whirl the air (Fig. 7). This rules out furnaces with resistors or radiant combustion tubes in the furnace chambers. The requirement of program control eliminates the possibility of direct firing. The furnaces, then, must have a separate heating chamber in which resistors or burners are located. Hot air or combustion gases are circulated through the charge by means of a powerful fan.

Furnace Types Compared

For individual exposure of the casting, convection furnaces generally do not offer any large advantage as compared with radiation furnaces.

Radiation Furnaces. If the temperatures are too high for convection furnaces, and if conduction furnaces (salt bath) must be ruled out, then the only type of furnace left is the radiation furnace. These may be resistor furnaces, radiant-tube furnaces, muffle furnaces, or direct-heat-fuel furnaces. The next problem to be considered is the type selection of such furnace (over stationary furnaces).

If it is possible to store castings so that for a period of at least several hours the continuous furnace can be loaded with castings of equal size and shape, then the continuous furnace with individual exposure of the castings is the desirable solution. If the storage of castings proves impossible, then the continuous furnace must often be ruled out because it may not work satisfactorily if pieces of different size pass through it. Moreover, in many plants only batch-type furnaces are available at present and funds may not be available for immediate replacement.

More satisfactory results may be obtained from batch-type furnaces if special attention is paid to the manner of loading and if special care is taken in the arrangement of the heating means.

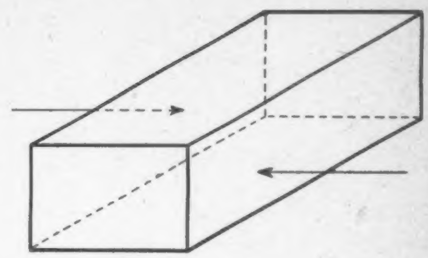


Fig. 8—Correct heating procedure for rectangular pile of castings.

A difficulty frequently encountered is that the corners of the rectangular charge may heat more rapidly and to a higher temperature than the remainder of the charge surface. This higher temperature may exceed the permissible maximum. In order to avoid this, it is desirable to heat only two, not four or six, sides of the rectangular pile of castings (Fig. 8). In the drawing, heating from two sides is shown. The same conditions would prevail if only top and bottom or only front and rear were heated. The other four sides of the furnace not used for heating the castings should be heated only to the extent of providing for heat lost through walls.

Heating Uniformity

The thickness across which heating occurs is of decisive influence on the uniformity obtained. Generally speaking, the heating times necessary to obtain a given degree of uniformity change with the square of the heated thickness of an individual casting or a pile. In the case of heating one casting only, no further comment is necessary. However, if a pile of castings is heated, the decrease in the thickness of the pile will lead eventually to the point. Where only one casting remains, then the heating time to obtain the same uniformity within the casting is still further and greatly reduced.

One method of improving the operation of batch-type furnaces is in loading smaller piles, which will heat much faster to the same uniformity as previously, instead of utilizing the full height of the furnace by loading the thickest pile possible. Uniformity can be improved considerably by slightly reducing the

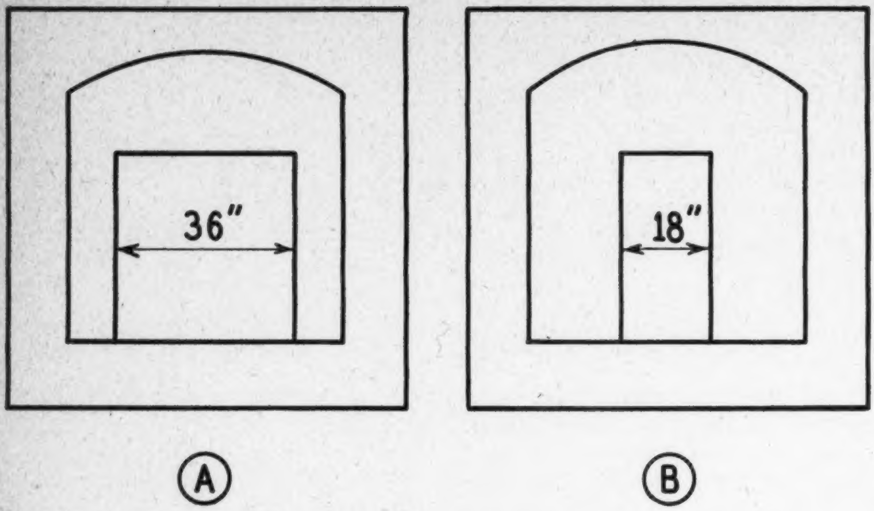


Fig. 9—Size of charge in box type furnace. A—3 ft., heating time, 8 hr. B—1½ ft., heating time, 2 hr.

furnace temperature and increasing the time of the charge.

As an example, let us say that a furnace with heat on two sides only heats at present a 3-ft. pile of castings in a heating time of 8 hr. (Fig. 9A). If the width of the pile is reduced to 1½ ft., approximately the same uniformity would be obtained in 2 hr. of heating time (Fig. 9B).

Increasing the heating time to 3 hr. and simultaneously lowering the furnace temperature will result in two advantages; the same output will be heated in a total of 6 hr. (two batches of 3 hr. each) as compared with the previous 8-hr. period and, in addition, much more uniform castings are obtained. The disadvantage in the procedure is the increased labor of load-charging and discharging the furnace twice. This is a price that should be paid in order to improve the uniformity.

If the total heating time is several days so that the reduction of the size of the pile leads to heating times which are inconvenient because they interfere with the change of shifts, it may be necessary to add batch-type furnaces. If several furnaces are used, it is desirable to have furnaces of different size, which yields great flexibility.

Heating of castings in piles is undesirable from the point of view of uniform production.

Disadvantages usually inherent in this method can be partly overcome by using salt-bath furnaces if permissible, or furnaces with forced convection and program control.

If neither method is possible, then continuous furnaces should be applied. If they too cannot be used, special attention should be given to distribution of heating means and the thickness of the heated pile in radiation and combined radiation and convection furnaces.

Acknowledgments

The first draft of the manuscript was submitted to a number of foundrymen and valuable comments and criticisms were offered by the following: W. D. Bailey, Jr., Westlectric Castings, Inc., East Los Angeles, Calif.; G. K. Dreher, Ampco Metal, Inc., Milwaukee; W. Finster, Reading Steel Casting Div., American Chain & Cable Co., Reading, Pa.; J. W. Juppenlatz, Lebanon Steel Foundry, Lebanon, Pa.; G. A. Lillieqvist, American Steel Foundries, East Chicago, Ind.; J. T. MacKenzie, American Cast Iron Pipe Co., Birmingham, Ala.; G. P. Phillips, International Harvester Co., Chicago; H. A. Schwartz, National Malleable & Steel Castings Co., Cleveland; J. S. Vanick, International Nickel Co., New York; J. D. Wolzney, American Steel Foundries, East Chicago, Ind.; and L. Brown, Magnesium Fabricators Div., Bohn Aluminum & Brass Corp., Adrian, Mich. The author wishes to express his sincere gratitude for their cooperation.

DISCUSSION

Chairman: A. M. Fulton, Northern Malleable Iron Co., St. Paul, Minn.

Co-Chairman: C. F. Joseph, Saginaw Malleable Iron Div., General Motors Corp., Saginaw, Mich.

Dr. H. A. Schwartz[1]: I should like to endorse and emphasize some of the things Dr. Paschkis said. It is not sufficient just to build a malleable annealing furnace. If you want uniformity of temperature, you cannot have very quick heating because, even if everything else were right, you would still have to maintain temperature gradient in the casting. If all other gradients were eliminated, the casting gradient would remain.

It is suggested that we make an hourly charge, this in one dimension. Dr. Paschkis made reference to the fact that with the continuous furnace of the conveyor type, we have a charge of only one or two castings thick.

The points he makes are eminently true, and they are of enormous importance. Each one of those factors means that you have a small cross-section; a small furnace; that you are confronted with what finally amounts to a very considerable investment in your heat-treating equipment.

You are confronted with that, and you finally end up with the question: Where is the point at which it is cheaper to have something less ornate in furnace equipment and a longer annealing cycle to do the work, as compared with shortening your annealing cycle and trying to economize by the greater annual output of a given unit?

I think all users of malleable castings, most sellers of furnaces for malleable castings, and some malleable foundrymen do not adequately understand that there is this balance of cost of the product and time in which you can deliver a product, and that, generally speaking, if you are going to stay in business you have to approach the economic minimum.

The customer is very seldom willing to pay any more money to get the casting sooner. Naturally we reach the point where increased output costs money but the product cannot be sold at the price necessary to meet the costs of production.

The conditions that Dr. Paschkis outlined are such that they will help evaluate the relative merits of one type of furnace against the other, and aid in selecting that particular equipment which, for a particular industrial condition, produces the best and most salable product.

In the days when I had quite a little contact with Charles Kettering, his statement was that that material is the best material which actually fulfills the minimum requirements for the least price. His statement is also true of heat-treating.

Dr. Paschkis: I want to thank Dr. Schwartz for his remarks upholding the tendency of this paper. I particularly agree with his statement on the necessity of finding an economic optimum between quality and cost of production.

Member: Some people claim that it is impossible to circulate hot gases with fans, while others claim that you can. Would you care to comment on that?

Dr. Paschkis: I think there are enough furnaces in operation to show that you can circulate gases up to a temperature of 1700° F. Beyond that, fans do not seem to stand up well.

[1]National Malleable & Steel Castings Co., Cleveland.

R. V. OSBORNE[2]: The conditions in the heat treating of malleable iron are somewhat different than for heat treating some other metals. I suppose you are implying that the design of the furnace should also include the efficiencies and temperature differentials you get in your casting mass, on cooling as well as on heating. Would not that have some bearing, in cooling slowly through quite a range, on how you would design your furnace?

DR. PASCHKIS: Yes. If you cool in the furnace, very definitely it would, and for malleable iron you have to do so. What was said here for heating holds true for cooling. It is still more difficult in cooling than heating to obtain uniformity in the charge. In heating, it is by and large a question of time alone. In cooling you are bound to get great differences if you take the casting out of the furnace. If you cool in the furnace, it would be the same proposition. It is conceivable to build furnaces which would allow the temperature to drop very slowly until, at a known critical value, it would permit the temperature to drop rapidly.

[2]Lakeside Malleable Castings Co., Racine, Wis.

L. C. KIMPAL[3]: Is under-firing alone better than over- and under-firing for more uniform heating of the mass?

With two sets of burners, one set firing under the arch and one set firing under the hearth, using twin nozzle burners below, shutting off the gas on one nozzle and introducing air only through this nozzle do you not get pretty even distribution in the furnace through a wide range of temperature, say from 600 to 2000° F.? This method of firing is common practice in the heat treating field.

DR. PASCHKIS: Under-firing is frequently better than over-firing because, by natural convection, there will be some heating also from the top. Even if you have only one piece, if you heat from two sides it is better than from one side alone, but it is not better to heat from three, four, or six sides. Heating from two sides is better than from one side.

The second question is one of having three sets of burners. It is possible to work it out as described. However, I do not think you could set up a general rule to that effect. Apparently you limit your remarks to one specific furnace design.

[3]Rochester Gas & Electric Corp., Rochester, N. Y.

STEERING GROUP
Shapes Plans for Gray Iron Division

PROMPT ACTION toward reorganization of A.F.A. Gray Iron Division and its committees and shaping of the gray iron program for the 1947 Convention was taken by the Division Steering Committee, meeting recently at the Hotel Statler, Buffalo, with Division Chairman T. E. Eagan, Cooper-Bessemer Corp., Grove City, Pa., presiding.

Cardinal points of a plan for revised divisional organization were presented at the request of Chairman Eagan by S. C. Massari of the National Office staff; and the committee, following discussion of the suggestions, reached a number of important decisions:

Executive Committee of the Division is to consist of the Division Chairman, Vice-Chairman and Secretary, the chairmen of Division committees, and three members selected at large. F. J. Walls, International Nickel Co., Detroit, and W. E. Mahin, Armour Research Foundation, Chicago, were named members at large.

An advisory group, composed of men prominent in the gray iron industry, who might be called upon for special assignments by the Division Chairman or Executive Committee, was established. Selected by unanimous vote as members of this group were:

A. L. Boegehold, General Motors Research Laboratories, Detroit; John Bolton, The Lunkenheimer Co., Cincinnati; Hyman Bornstein, Deere & Co., Moline, Ill.; V. A. Crosby, Climax Molybdenum Co., Detroit; R. F. Harrington, Hunt-Spiller Mfg. Co., Boston; Max Kuniansky, Lynchburg Foundry Co., Lynchburg, Va., A.F.A. National Vice-President; J. T. MacKenzie, American Cast Iron Pipe Co., Birmingham, Ala.; C. H. Lorig, Battelle Memorial Institute, Columbus, Ohio; G. P. Phillips, International Harvester Co., Chicago; F. G. Sefing, International Nickel Co., New York; and E. K. Smith, consulting metallurgist, Beverley Hills, Calif.

Division Secretary W. E. Mahin was relieved of that capacity at his own request, due to the pressure of daily responsibilities; and Mr. Massari agreed to undertake the duties of recording secretary for the Executive Committee in a non-member status.

Committee Plans

Purpose and activities of Division committees were discussed thoroughly, and decisions were reached as to which were to be continued, which placed on standby status, and what new committees were to be organized.

Committee on Microstructure of Cast Iron will continue; and H. W. Lownie, Jr., Battelle Memorial Institute, was named Chairman. It was suggested that technique of polishing be surveyed and a recommended practice prepared.

Cupola Research Committee, under chairmanship of R. G. McElwee, Vanadium Corp. of America, Detroit, now enters the third phase of its work, canvassing the field and carrying out research already indicated as necessary by earlier studies in preparation of a bibliography on cupola operations and publication of the CUPOLA OPERATIONS HANDBOOK.

Also retained are the *Committee on Section Size Relationship* and the *Committee on Analysis of Casting Defects.*

Two committees were placed on a standby status, with chairman appointed in order that the groups may be reactivated quickly if necessary: *Committee on High Temperature Properties of Cast Iron* and *Committee on Inoculation.*

Five new committees, on *Pig Iron Qualities, Gating and Risering, Heat Treatment of Cast Iron, Cleaning of Castings* and *Test Bar Design,* will be established to undertake activities in regard to current aspects of technology of great interest to foundrymen.

Convention Papers

Program and Papers Committee, headed by Division Vice-Chairman R. J. Allen, Worthington Pump & Machinery Corp., Harrison, N. J., will consult appropriate committees for recommendations and review of papers particularly applicable to their fields. A standard form to accompany a technical paper and be executed by the reviewer will be drawn up in order to facilitate the consideration of papers.

Program for the 1947 Convention was discussed, and it was tentatively decided to schedule four gray iron sessions, of three papers each. Two sessions are to be symposiums, one on heat treatment and the other on welding practices, and the remaining two sessions are to be general. Subjects for the technical papers were considered, and a number of papers were proposed.

★ NEW A. F. A. MEMBERS ★

(Covering the Period from June 15 to July 1)

• Fourteen chapters added new names to the ever-growing roster of A.F.A. members. This month's list, covering the latter part of June, contains 34 members; 24 of whom are in chapter territories.

BIRMINGHAM DISTRICT CHAPTER

LaVerne Cason, Molding Foreman, Jackson Industries, Inc., Production Foundries Div., Birmingham, Ala.

John Goldman, Maintenance Fore., Jackson Industries, Inc., Production Foundries Div., Birmingham, Ala.

Harold Johnson, Fdry. Supt., Jackson Industries, Inc., Production Foundries Div., Birmingham, Ala.

Paul Leatherwood, Cons. Fore., Jackson Industries Inc., Production Foundries Div., Birmingham, Ala.

Lee Roueche, Conversion Fore., Jackson Industries, Inc., Production Foundries Div., Birmingham, Ala.

CENTRAL ILLINOIS CHAPTER

Harrington G. Milland, Superior Foundry Co., East Peoria, Ill.

CHICAGO CHAPTER

Donald B. Murray, Apprentice, Continental Foundry & Machine Co., East Chicago, Ind.

DETROIT CHAPTER

William Mills Todd, Jr., Ind'l. Rel. Mgr., General Magnetic Corp., Detroit.

METROPOLITAN CHAPTER

John Alico, Dir. Res. & Dev., National Magnesium Corp., New York.

NORTHEASTERN OHIO CHAPTER

Leo F. Friedel, Lake City Malleable Inc., Ashtabula, Ohio.

NO. ILLINOIS & SO. WISCONSIN CHAPTER

Ralph M. Lightcap, Mgr., Rupp Pattern Co., Rockford, Ill.

ONTARIA CHAPTER

Wm. Skinner, Jr., Coreroom Fore., Otaco Ltd., Orillia, Ont.

S. C. Whithard, Met., Otaco Ltd., Orillia, Ont.

ST. LOUIS DISTRICT CHAPTER

H. D. Stedelin, Vice-Pres., Centralia Foundry Corp., Centralia, Ill.

SOUTHERN CALIFORNIA CHAPTER

Edward H. Kullos, Supt., Mir-O-Col Alloy Co., Los Angeles.

John L. Mershon, Salesman, Simonds Saw & Steel Co., Los Angeles.

TWIN CITY CHAPTER

Sol Kronick, Partner, Harry A. Brown Co., Minneapolis.

A. D. Stimmler, Dist. Repr., American Foundry Equipment Co., Mishawaka, Ind.

J. A. Willcox, Engr., Minnesota Micaceous Products, Inc., Minneapolis.

WESTERN MICHIGAN CHAPTER

William Buller, Partner, White Lake Foundry, Montague, Mich.

Gerald Garvelink, Partner, White Lake Foundry, Montague, Mich.

WESTERN NEW YORK CHAPTER

Anthony Czajka, Coremaker, Worthington Pump & Machinery Corp., Buffalo, N. Y.

WISCONSIN CHAPTER

Robert L. Adams, Fdry. C/R Engr., The Van Brunt Mfg. Co., Horicon, Wis.

John J. Janes, Plant Engr., Standard Foundry Co., Racine, Wis.

OUTSIDE OF CHAPTER

Louis S. Altvater, Chief Chemist, Reliance Steel Casting Co., Pittsburgh, Pa.

W. J. Coffman, Met., Patch Wegner Co., Inc., Rutland, Vt.

James A. Dalzell, Asst. Cleaning Dept. Supt., Reliance Steel Casting Co., Pittsburgh, Pa.

Library, Oklahoma Agricultural & Mechanical College, Stillwater, Okla.

Frank J. Snyder, Asst. Foundry Supt., Reliance Steel Casting Co., Pittsburgh, Pa.

Edward V. Somers, Mfg. Engr., Westinghouse Electric Corp., Trafford, Pa.

Argentina

Jose Robiola, Engr., Cia Industrial de Electricidad, Buenos Aires.

Czechoslovakia

Robert Kleinzeller, Met., Mor-o-Strava Foundry, Witkowitz.

England

The Librarian, The University, Edgbaston, Birmingham.

Holland

Machinefabriek Gebr. Stork & Co., AFD Reclame, Hengelo/Q.

FOUNDRY PERSONALITIES

L. C. Smith, formerly associated with Peninsular Grinding Wheel Co., Chicago, has been appointed Wisconsin sales representative, Harry W. Leighton Co., Milwaukee. Mr. Smith, recently re-elected Secretary, Chicago A.F.A. chapter, has resigned that position due to the transfer of location.

Henry James

Henry James, foreman, metal pattern department, American Steel Foundries, Alliance, Ohio, retired recently after 35 years service in that capacity. Fellow employees honored Mr. James with a dinner, at which **D. T. Born,** general foreman, pattern department, was speaker of the evening, reviewing the former's career, and **Fred Throne** acted as master of ceremonies.

Clyde Williams **W. J. Grede**

W. J. Grede, president, Grede Foundries, Inc., Milwaukee, was recently elected a director of the National Association of Manufacturers.

Clyde Williams, director, Batelle Memorial Institute, Columbus, Ohio, was recently honored with award of the honorary degree of doctor of science during convocation ceremonies at the University of Utah, Salt Lake City, in recognition of war and peacetime contributions to American technology. The degree was presented to Dr. Williams, an alumnus of the school, by **Dr. A. R. Olpin,** university president, who cited the former's accomplishments in research administration and in direction of activities of the war metallurgy committee of the National Academy of Sciences and the National Research Council.

A. L. Boeghold **Nathan Lester**

A. L. Boeghold, Research Laboratories Div., General Motors Corp., Detroit, a member of the Executive Committee, A.F.A. Gray Iron Division, has been nominated for president, American Society for Metals. **F. B. Foley,** Midvale Co., Philadelphia, has been nominated for vice-president; and **W. H. Eisenman** for another term as secretary.

A. J. Edgar has been appointed works manager, Benton Harbor Malleable Industries, Inc., Benton Harbor, Mich. Well known to A.F.A. as a member of many of its national committees, Mr. Edgar recently resigned as technical advisor, Gray Iron Founders' Society, Washington, D. C., as reported in AMERICAN FOUNDRYMAN, June, 1946.

Nathan Lester is president, **H. G. Coffey** and **D. White** vice-presidents, and **L. L. Dalbey** secretary-treasurer of Lester-Aetna Die Co., Warren, Ohio, new firm name of the tool and die division of Lester Engineering Co., Cleveland. The division, owned jointly by the Lester company and Aetna-Standard Engineering Co., Warren, Ohio, was recently reorganized and moved from Cleveland.

Samuel Appelby **R. L. Salter**

Samuel Appelby, associated for the past eight years with Buffalo Foundry & Machine Co., Buffalo, N. Y., as superintendent, has been appointed works manager, Colonial Foundry Co., Louisville, Ohio. An active member of A.F.A., Mr. Appelby serves on the Core Test Committee, Foundry Sand Research Project, and on the Program and Papers Committee, Gray Irion Division.

R. L. Salter, since 1944 general superintendent and works manager, Southern Wheel Div., American Brake Shoe Co., New York, has been appointed vice-president of the division. A graduate of Alabama Polytechnic Institute, Auburn, Mr. Salter joined the Southern Wheel organization in 1924. He will be in charge of operations for the division's nine United States plants, and responsible for production of chilled tread car wheels.

R. N. Watt has been named general manager of sales for Baldwin Locomotive Works, Eddystone, Pa., and **J. M. Sturges** has been named district manager, northeastern district, with headquarters in New York and responsible to Mr. Watt.

R. L. Wilcox, who served as zinc consultant to the War Production Board during the war and was pre-

(Continued on Page 103)

★ CHAPTER ACTIVITIES ★

news

Southern California

J. B. Morey
International Nickel Co.
Chairman, Publicity Committee

EXCEPTIONAL ATTENDANCE for an outstanding technical discussion and the installation of chapter officers* marked the last regular meeting of the season for Southern California A.F.A. chapter, held June 14 at Roger Young Auditorium, Los Angeles.

Speaker of the evening on "Solidification of Metals" was Dr. H. A. Schwartz, National Malleable & Steel Castings Co., Cleveland, Chairman, A.F.A. Committee on Heat Transfer and member Executive Committee, A.F.A. Malleable Division. Contributing to the discussion on the same topic was Paul Siechert, Alhambra Foundry Co., Alhambra, Calif.

Participation of foundrymen during the question and general discussion period was evidence of current broad interest in aspects of the solidifying of molten metal in the mold.

*Listed on page 91, AMERICAN FOUNDRYMAN, July, 1946.

Oregon

A. R. Prier
Oregon Brass Works
Chapter Secretary

ANNUAL MEETING of Oregon A.F.A. chapter, held June 20 in Portland, featured an unusual technical discussion as J. V. Savage and C. A. Anderson, both of Crown Zellerback Corp., Portland, described the contributions of the foundry industry to advances in pulp paper manufacturing methods.

The speakers presented motion pictures of production of wood pulp at their firm's Camas Mill, and emphasized close relationship between the foundry and pulp industries. Specifically cited was the development and introduction of stainless steel castings.

J. V. Savage, sulphite superintendent, Crown Zellerback Corp., Portland, Ore., handles general discussion period on role of foundry products in the paper industry, at the June 20 meeting of Oregon A.F.A. chapter, held in Portland.

At the June 20 meeting of Oregon A.F.A. chapter, in Portland, J. W. Cable research director, Induction Heating Corp., gets a point across in the humorous manner during his coffee talk on "Dielectric Core Baking." Joining in the laugh are (seated, left to right), H. H. Richmond, Electric Steel Foundry, and Chapter Chairman W. R. Pindell, Northwest Foundry & Furnace Co., both of Portland.

Another aspect of foundry technology was emphasized in the coffee talk by J. W. Cable, director of research, Induction Heating Corp., who discussed "Dielectric Core Baking." Uniform, controlled temperature throughout the sand and greater speed in baking were given as advantages of the method.

Business session of the evening was concerned with election of officers and directors. W. R. Pindell, Northwest Foundry & Furnace Co., Portland, was re-elected *Chairman.*

H. L. Tatham, Pacific Steel Foundry, Portland, currently serving as a chapter Director, was elected *Vice-Chairman;* and F. A. Stephen-

son, Dependable Pattern Works, of the same city, also serving as a current Director, was named *Secretary-Treasurer.*

New *Directors* are: D. H. L. Beahler, American Brake Shoe Co.; L. E. Bufton, Silica Products Co.; and A. B. Holmes, Crawford & Doherty Foundry, all of Portland.

R. R. Haley (left), Advance Aluminum & Brass Co., Los Angeles, retiring chapter President, turns the gavel over to his successor, President-Elect W. D. Emmett, Los Angeles Steel Castings Co., of that city, at the June 14 meeting of Southern California chapter, in Roger Young Auditorium, Los Angeles. Paul Siechert (extreme right), Alhambra Foundry Co., Alhambra, Calif., one of the evening's speakers, seems to be reviewing either his subject or the chapter's successful season which was concluded with the meeting.

Western New York

L. A. Merryman
Tonawanda Iron Corp.
Chapter Secretary

TWO ANNUAL HIGHLIGHTS of the chapter season for Western New York A.F.A. chapter, the Spring Dinner Dance and Annual Picnic and Election of Officers, May 25 at the Buffalo Trap & Field Club, Buffalo, and June 15 at Kudara Farms, Hamburg, respectively, brought a successful and pleasant close to the year's activity. Attendance for the dance was in the neighborhood of 200, and the event was adjudged an outstanding success; while approximately 300 turned out for the picnic, enjoying the unusually fine weather and a full program of games and other entertainment.

Hold Elections

Picnic activities were interrupted for the business session, presided over by Chapter Chairman A. H. Suckow, Symington-Gould Corp., Depew, N. Y., and recommendations of the nominating committee, which were presented at the meeting of May 3, were unanimously accepted.

Named as *Chairman* was H. C. Winte, Worthington Pump & Machinery Corp., Buffalo, chapter Vice-Chairman for the past season and well known to A.F.A. for his activities on committees in the Gray Iron Division.

E. R. Jones, Lumen Bearing Co., Buffalo, was elected *Vice-Chairman.*

L. A. Merryman, Tonawanda Iron Corp., North Tonawanda, N. Y., continues as *Secretary,* and M. W. Pohlman, Pohlman Foundry Co., Buffalo, as *Treasurer.*

Elected chapter *Directors,* to serve a three-year term, were: J. C. Nagy, Charles C. Kawin Co.; L. C. Smith, Lakeside Bronze, Inc.; and J. R. Wark, Queen City Sand & Supply Co., all of Buffalo.

Retiring Chairman Suckow was elected a *Director* for a one-year term.

Expressing his thanks to the membership for their excellent cooperation during the year, Chairman Suckow presented the gavel to his successor, Mr. Winte, who made a short speech of acceptance. F. E. Bates, Worthington Pump & Machinery Corp., himself a former chapter Chairman, then presented

First annual Ladies Night at Southern California chapter, May 25, at the Lakewood Country Club, Los Angeles.

Mr. Suckow with a past chairman's pin and the thanks and appreciation of the chapter, following which the business session was adjourned.

Picnic activities were under the direction of J. R. Turner, Queen City Sand & Supply Co., and his committee.

Central New York

J. A. Feola
Crouse-Hinds Co.
Chapter Reporter

VARIED ACTIVITIES shaped up an interesting program for some 150 members and guests of Central New York A.F.A. chapter attending the Annual Meeting, June 14, in Syracuse, N. Y.

Visitation to a modern foundry, that of the Crouse-Hinds Co., host to chapter for the day, was the first event for the foundrymen, who demonstrated keen interest in the thoroughly mechanized plant.

As the various groups completed their tours, they were directed to Hinerwadel's Grove, where sports events and a clambake were held.

Business portion of the meeting was devoted to election of chapter officers and directors for the 1946-47 season. E. E. Hook, Dayton Oil Co., Syracuse, chapter Vice-Chairman for the past season, was elected *Chairman;* and R. A. Minnear, Ingersoll-Rand Co., Painted Post, N. Y., currently serving as Secretary, was advanced to *Vice-President.*

C. M. Fletcher, Fairbanks Co., Binghamton, N. Y., was named *Secretary.*

M. H. Hollenbeck, Kennedy Valve Mfg. Co., Elmira, N. Y., continues as *Treasurer;* while I. F. Vergamini, Goulds Pumps, Inc., Seneca Falls, N. Y., who completes a term as chapter Director with this season, was named *Program Chairman,* non-ferrous group.

Elected to three-year terms as chapter *Directors* were: E. G. White, Crouse-Hinds Co., retiring chapter Chairman; W. G. Parker, Elmira Foundry Co., Elmira; and D. J. Merwin, Oriskany Malleable Iron Co., Oriskany, N. Y.

Eastern Canada-Newfoundland

G. D. Turnbull
Shawinigan Foundries, Ltd.
Chairman, Publicity Committee

APPRENTICES SHARED the spotlight with new officers and directors as Eastern Canada and Newfoundland A.F.A. chapter held elections and presented prize awards at its Annual Meeting, May 1, in the Mount Royal Hotel, Montreal.

Successful contestants in the apprentice contest sponsored jointly by A.F.A. and the Montreal Technical School received their prizes. Sec-

Rounding out a successful season for Western New York chapter: Right, enjoyment is evident in these scenes from the Annual Dinner Dance, held May 25 at Buffalo Track and Field Club, Buffalo. Left, weatherman cast a beautiful day for the 300 foundrymen attending the Annual Picnic, June 15, at Kudara Farms, Hamburg, N. Y., when elections were held and a sports program featured softball games, horseshoe pitching contests and prize awards in many other entertaining contests.

(Photos courtesy Jack Heysel, E. J. Woodison Co.)

ond, third and fourth year leaders, respectively, in each class, were: Pattern Making, R. Theriault, Montreal Technical School; L. Mossier, Acme Pattern & Woodworking Co.; and G. Marquette, Montreal Technical School. Iron Molding, L. Limoges, Melanson Foundry; M. Tamburine, Warden King, Ltd.; and H. Lalonde, H. Walford, Ltd. Nonferrous, E. Jones, Empire Brass Foundry; P. Blais, Montreal Technical School; and C. Corriveau, of that school. Steel Molding, E. Power, Canadian Car & Foundry Co. Ltd.; and J. P. Laberge, of the same firm. All are of Montreal.

Earlier, following reports of the committee chairmen, Chapter Chairman G. E. Tait, Dominion Engineering Works, Ltd., Lachine, Que., summarized chapter activities of the season; following which the meeting proceeded with elections.

Current Chapter Vice-Chairman Henri Louette, Warden King, Ltd., was elected *Chairman* for the coming year; and A. E. Cartwright, Robert Mitchell Co. Ltd., St. Laurent, Que., who completes a term as a chapter Director with this season, was named *Vice-Chairman.*

R. E. Cameron, Webster & Sons, Ltd., Montreal, continues as *Secretary.*

Elected *Treasurer* was L. G. Guilmette, Canadian Foundry Supplies & Equipment Co. Ltd., Montreal.

Directors, elected to serve a three-year term, are: C. C. Brisbois, foundry consultant, Montreal; W. L. Bond, Ottawa Car & Aircraft, Ltd., Ottawa; and John Shewan, Canadian Car & Foundry Co. Ltd.

Following the introduction of, and a brief talk by the incoming chairman, Mr. Louette, two interesting movies were shown. One of the pictures dealt with "Die Casting," the other with "Refining and Casting of Magnesium."

View of the attendance for Old Timers and Apprentices Night, May 16 meeting of Wisconsin A.F.A. chapter at the Hotel Schroeder, Milwaukee.
(Photo courtesy of John Bing, A. P. Green Fire Brick Co.)

Texas

R. H. Glenny
Alamo Iron Works
Chairman, Publicity Committee

OFFICERS AND DIRECTORS for the coming year were announced at the last 1945-46 luncheon meeting of Texas A.F.A. chapter, held June 20, at the Golfcrest Country Club, Houston, with Chapter Chairman E. P. Trout, Lufkin Foundry & Machine Co., Lufkin, Texas, presiding and attendance of 35 members and guests.

At the request of Chairman Trout, A.F.A. National Director F. M. Whittlinger, Texas Electric Steel Casting Co., Houston, assisted Chapter Secretary-Treasurer Harry Wren, R. Lavin & Sons, Inc., Houston, in making the official count of the chapter election ballots.

W. M. Ferguson, Texas Electric Steel Casting Co., who has served as Vice-Chairman for the past season, was elected *Chairman.*

Named *Vice-Chairman* for 1946-47 was L. H. August, Hughes Tool Co., Houston.

Harry Wren continues as *Secretary-Treasurer.*

New *Directors* are: G. E. Bryant, Jr., Oil City Brass Works, Beaumont, Texas; L. M. Orin, East Texas Electric Steel Casting Co., Longview, Texas; R. H. Glenny, Alamo Iron Works, San Antonio, Texas; and DeWitt McKinley, McKinley Iron Works, Fort Worth, Texas.

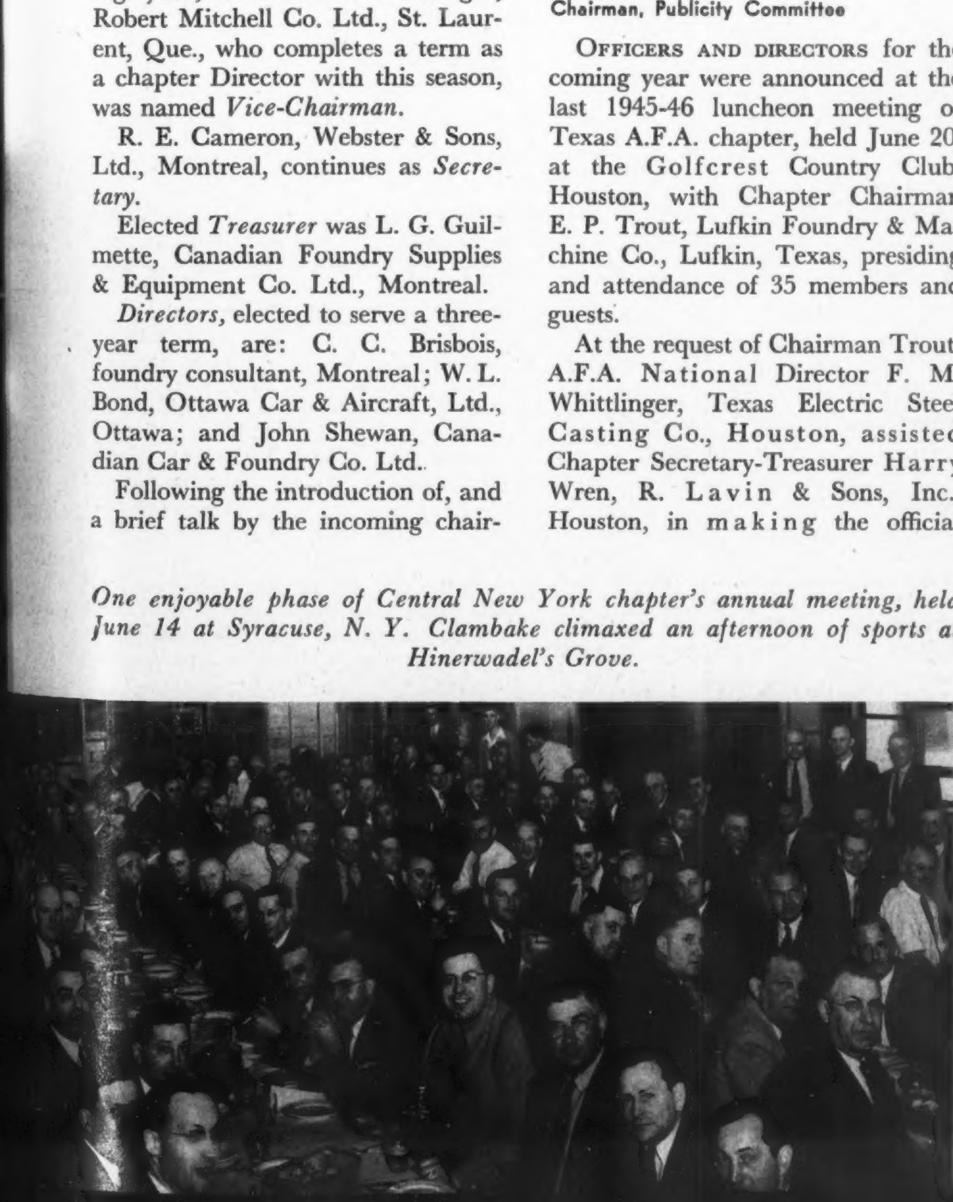
Introducing the new Chairman, Mr. Trout expressed warm appreciation for the other's good work as program chairman during the previous season, and conveyed the thanks of the chapter. Mr. Ferguson, in reply, reviewed briefly the benefits of meetings and urged members to submit their suggestions in regard to improving programs.

Appointments of committee chairmen were announced by Mr. Ferguson: *Entertainment,* L. N. Crim, East Texas Electric Steel Co.; *Publicity,* R. H. Glenny; *By-Laws,* F. M. Whittlinger; *Membership,* W. J. Temple, Kincaid-Osburn Electric Steel Co., San Antonio.

Mr. Whittlinger, expressed to Mr. Trout the appreciation of the chapter for his fine work during the past season, presented him with the past chairman's pin.

General discussion of the meeting centered on the question of increasing chapter membership. A number of suggestions were advanced as to methods of interesting foundrymen in programs of the chapter.

One enjoyable phase of Central New York chapter's annual meeting, held June 14 at Syracuse, N. Y. Clambake climaxed an afternoon of sports at Hinerwadel's Grove.



ABSTRACTS

NOTE: The following references to articles dealing with the many phases of the foundry industry, have been prepared by the staff of *American Foundryman*, from current technical and trade publications.

When copies of the complete articles are desired, photostat copies may be obtained from the Engineering Societies Library, 29 W. 39th St., New York, N. Y.

Aluminum-Base Alloys

Centrifugal Casting. *(See Centrifugal Casting.)*

Die Castings. *(See Die Castings.)*

Die Castings. *Dimensional Stability of Aluminum Alloy Die Castings,"* Die Casting, June, 1946, vol. 4, no. 6. pp. 19-20, 40.

Dimensional instability is largely the result of growth in volume resulting from breakdown of solid solutions and the release of lock-up stresses resulting from casting. Proper heat treatment to improve stability is described.

Porosity. Nitzsche, Eugene, *"The Origin of Micro-Cavities,"* Light Metal Age, January, 1946, vol. 4, no. 1, pp. 12-13, 31.

A translation from Die Giesserei which discusses some of the lesser known ways in which hydrogen and other gases which cause cavities and porosity may be picked up in the light metal foundry. Methods for prevention and elimination of these causes for porosity are given.

Binders

Silicon Esters. Shaw, Clifford, *"The Application of Ethyl Silicate to Foundry Practice,"* Foundry Trade Journal, January 10, 1946, vol. 78, no. 1534, pp. 31-33.

The author explains the chemistry of silicon esters and discusses the possibilities of ethyl silicate as a binder for mold materials.

Brass and Bronze

Shrinkage Porosity. Pell-Walpole, W. T., *"Chill Cast Bronzes,"* Metal Industry, May 3, 1946, vol. 68, no. 18, pp. 346-348.

A graphical representation of the results of shrinkage and entrapped gas-porosity.

Tensile Strength. Pell-Walpole, W. T., *"Chill Cast Bronzes,"* Metal Industry, April 26, 1946, vol. 68, no. 17, pp. 323-324.

A graphical correlation of percentage porosity and tensile strength of two series of chill cast phosphor bronzes.

Centrifugal Casting

Aluminum-Base Alloys. Basch, E. J., Blackwood, Peter, and Perkins, John, *"Centrifugal Casting Aluminum,"* Modern Metals, January, 1946, vol. 1, no. 12, pp. 14-16.

Description of casting process, engineering characteristics of finished casting, manufacturing problems, equipment, and metal control. The article also includes a bibliography on centrifugal casting.

Chemical Analysis

Sulphur. Hedberg, James, and Schwartz, H. A., *"Combustion Method for Sulphur Determination in White Cast Iron,"* American Foundryman, January, 1946, vol. 9, no. 1, pp. 63-64.

Sulphur content of malleable iron can be determined accurately within 12 minutes by igniting the sample in oxygen, absorbing the sulphur dioxide formed in a neutral silver nitrate solution, and titrating with a standard sodium hydroxide solution.

Clays

British. Davies, W., and Rees, W. J., *"British Bonding Clays,"* The Iron and Steel Institute, Advance Copy, February, 1946, 9 pp.

In an investigation of the characteristics of indigenous bonding clays, three typical groups of bonding clays were examined. The range of properties of synthetic sands prepared with these clays is indicated.

Cleaning

Gray Cast Iron. *"Removing Sand and Scale from Gray Iron Castings,"* The Iron Age, May 16, 1946, vol. 157, no. 20, p. 51.

A description of the DuPont sodium hydride descaling process for removing sand and scale.

Control

Records. Laurie, R. D., *"Technical Records in the Foundry,"* Foundry Trade Journal, April 11, 1946, vol. 78, no. 1547, pp. 387-390.

The author discusses the importance of carefully-maintained records to foundry control.

Cores

Malleable Foundry. Welander, Eric, *"Malleable Iron Foundry Cores,"* American Foundryman, April, 1946, vol. 9, no. 4, pp. 112-114.

Raw materials, mixtures, baking, cooling, finishing, and quality control for cores in the malleable iron foundry.

Costs

Methods. Lee, Ralph L., *"Price Per Pound, Price Per Piece, Which?"* American Foundryman, April, 1946, vol. 9, no. 4, pp. 136-138.

The author presents his cost methods with examples based on logical and basically sound assumptions, in order to show that the price per piece is more equitable than the price per pound.

Defects

Steel. *(See Steel.)*

Die Castings

Aluminum-Base. *"Aluminum Alloy Die Casting."* American Foundryman, April, 1946, vol. 9, no. 4, pp. 103-111.

Fundamental information about die casting, including dies, casting ejection mechanism, die casting machines, metal volume, metal temperature control, metal analysis control, difficult-to-cast alloys, redesigning, trimming die castings, inspection, applications, surfaces, and finishes.

Die Casting

Aluminum-Base Alloy. *(See Aluminum-Base Alloys.)*

Gray Cast Iron

Applications. *"Cast Iron in the Mining Industry,"* Canadian Metals and Metallurgical Industries, March, 1946, vol. 9, no. 3, pp. 30-31.

The realization that the service properties of cast irons are far better than what might be expected from test bar results has been responsible for extending its field of use to many mining and one dressing applications. These applications take advantage of its good fatigue strength, high damping capacity, ability to distribute localized stress, heat resistance, abrasion resistance, and relatively low cost.

Microstructure. Mahin, W. E., and Lownie, H. W., Jr., *"Microstructure Related to Properties of Cast Iron,"* American Foundryman, January, 1946, vol. 9, no. 1, pp. 20-28.

The properties of gray cast iron are dependent upon its microstructure. This can be changed by quenching and tempering treatments to improve strength and hardness.

Alloying elements may be used to develop microstructures of increased strength, hardness and wear resistance.

Properties. Herzig, Alvin J., *"Cast Iron—Modulus of Elasticity,"* American Foundryman, April, 1946, vol. 9, no. 4, pp. 134-135.

The author points out that cast iron is not a homogeneous material and hence do not exhibit a linear stress-strain relationship. There is a need for more work in determining the modulus of elasticity of gray cast iron.

Sand. *(See Sand.)*

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Foundry Personalities
(Continued from Page 89)

viously for 16 years Chicago technical representative for New Jersey Zinc Co., New York, has been appointed assistant factory manager, Gerity Michigan Die Casting Co., Detroit. Mr. Wilcox is author and co-author of numerous technical papers published by AIME, and has also written many technical articles for the trade press.

W. J. Kelly

W. F. Kelly has been appointed general superintendent of foundries, American Manganese Steel Div., American Brake Shoe Co., New York, and will make his headquarters in Chicago Heights, Ill., according to announcement of **J. L. Mullin,** vice-president of the division. Associated with the Manganese division in various capacities since 1925, Mr. Kelly was formerly manager of the New Castle, Del., plant and made his residence in that city.

R. L. Ogden, who has spent the past year modernizing a production jobbing gray iron foundry for National Foundry Co. Inc., Brooklyn, N. Y., in the capacity of plant manager, has joined Lester B. Knight & Associates, Chicago, as senior engineer, and will be concerned with industrial engineering work in foundries. Mr. Ogden, who has had 37 years experience in the foundry industry, was associated for 34 years with Stockham Pipe Fittings Co., Birmingham, Ala., starting as coreroom foreman and resigning, in 1943, as general superintendent of gray iron, malleable and brass foundries. He was with American Castings Co., Birmingham, in 1944, and moved to the National Foundry firm in 1945. One of the charter

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Foundry Personalities
(Continued from Page 103)

members of Birmingham A.F.A. chapter, Mr. Ogden has served as its Vice-Chairman and has been active in organizing apprentice training.

S. S. Silberg has been appointed head of the engineering department, South Park Foundry, South St. Paul, Minn. Recently released after four years active duty with the Navy, Mr. Silberg is a graduate in mechanical engineering of the University of Minnesota, Minneapolis. He was an active member of the A.F.A. student chapter at that school, serving as Secretary-Treasurer. In 1942, Mr. Silberg was a winner in the technical paper competition for student A.F.A. members, sponsored annually by Twin City chapter.

W. C. Kerrigan, associated since 1930 with International Nickel Co., New York, has been appointed manager, nickel sales department.

Obituaries

Harry C. Donaldson, partner in the firm of Brumley-Donaldson Co., Los Angeles, died recently at the age of 69. Well known to foundrymen of the Pacific Coast area, Mr. Donaldson had been associated with the industry since coming to the coast in 1922 to assume the sales managership of Speckles Brothers Commercial Co. In 1924, when the Speckles company sold their interest, Mr. Donaldson founded the H. C. Donaldson Co.; and then joined with E. L. Brumley to build the present organization.

Charles E. Cummings, assistant secretary, Raybestos-Manhattan, Inc., died June 6 at the age of 79. One of the 52-year "Pioneers" of the Manhattan Rubber Division, Passaic, N. J., Mr. Cummings began his career in the rubber industry in 1881 with New York Belting & Packing Co., New York. He joined the Manhattan firm as a bookkeeper in 1894, and, at the time of his death was the third oldest employee in the plant in terms of service.

Abstracts

(Continued from Page 94)

SULPHUR DETERMINATION. *(See Chemical Analysis.)*

Inspection

NONDESTRUCTIVE. Frear, Clyde L., and Lyons, Robert E., *"Non-Destructive Inspection of Castings,"* AMERICAN FOUNDRYMAN, April, 1946, vol. 9, no. 4, pp. 120-133.

A brief description and an outline of advantages and disadvantages of inspection methods including visual inspection, sound or percussion tests, impact tests, pressure tests, radiographic examination, magnetic inspection, electrical conductivity, penetrants and supersonics. The author discusses important factors in the intelligent application of these methods.

Magnesium-Base Alloys

CERIUM. Leontis, T. E., and Murphy, J. C., *"Properties of Cerium-Containing Magnesium Alloys at Room and Elevated Temperatures,"* Technical Publication No. 1995, METALS TECHNOLOGY, April, 1946, vol. 13, no. 3, 32 pp.

This paper presents the results of an extensive investigation on the properties of various cerium-containing magnesium alloys in both the cast and forged conditions. Data show the beneficial effects of increasing amounts of cerium on the mechanical properties of magnesium at elevated temperatures. The effects of heat-treatment on the properties of these alloys and the attendant changes in microstructure are discussed.

CONTROL. Partridge, G. B., *"Technical Control in a Magnesium Foundry,"* FOUNDRY TRADE JOURNAL, May 2, 1946, vol. 79, no. 1550, pp. 5-8.

A discussion of magnesium alloys, melting technique, sand preparation, molding methods, heat treatment, inspection methods and general pointers pertinent to minimizing scrap production.

MELTING. Nash, L. M., *"Melting Magnesium Alloys,"* AMERICAN FOUNDRYMAN, January, 1946, vol. 9, no. 1, pp. 61-62, 79.

A step-by-step review of the wet-flux, crucible, and sulphur-atmosphere methods of melting magnesium, with emphasis placed on the important points.

MICROPOROSITY. Eastwood, L. W., and Davis, J. A., *"Microporosity in Magnesium Alloy Castings,"* AMERICAN FOUNDRYMAN, April, 1946, vol. 9, no. 4, pp. 148-155.

A review of the general characteristics of microporosity, the factors involved, and the mechanism of formation and a discussion of the interrelation of the three main factors determining microporosity: (1) gas content of the melt, (2) alloy composition, and (3) degree of feeding provided.

POROSITY. *(See Aluminum-Base Alloys.)*

Mechanization

BRASS FOUNDRY. Lyons, Thomas, *"Mechanical Brass Foundry,"* CANADIAN METALS AND METALLURGICAL INDUSTRIES, February, 1946, vol. 9, no. 2, pp. 29-31.

The author relates how a foundry with insufficient floor space and unable to expand or employ more men, increased its production by means of mechanization.

This was accomplished by installing sand handling equipment, gravity conveyors, conveyor belts, and chain carrying belts.

Mold Drying

TORCH DRYING. Rogers, Frank C., *"Sand Mold Drying with Propane-Gas Torches,"* AMERICAN FOUNDRYMAN, January, 1946, vol. 9, no. 1, pp.

A propane-burning torch produces higher temperatures and cleaner mold surfaces than an oil torch, and hence reduces the time required for skin drying.

Patternmaking

DESIGN. Tharp, William E., *"Pattern and Allied Equipment,"* AMERICAN FOUNDRYMAN, January, 1946, vol. 9, no. 1, pp. 30-37.

Lower cost per unit is the greatest advantage of cast products. To maintain this cost advantage in the face of improved methods in other processes, the foundry must develop methods to produce castings at lower costs and to closer tolerances.

Close cooperation between the casting designer and the foundryman, to obtain greater casting accuracy and lower costs

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Abstracts

(Continued from Page 105)

through correctly designed patterns and the use of inter-changeable pattern and other equipment, is a factor for the foundryman's careful consideration.

Patterns

MATCH PLATES. Brisbois, C. C., *"Plaster Composition Match Plates,"* CANADIAN METALS AND METALLURGICAL INDUSTRIES, April, 1946, vol. 9, no. 4, pp. 22-26.

Plaster composition match plates are superior to metal match plates in many ways. The initial cost and finishing costs are lower while alteration can be made with greater ease. The author describes a plate made in a single frame and reinforced with steel strips, rather than wires.

PRACTICES AND EQUIPMENT. Padley, H., *"Is the Pattern Shop an Asset or a Liability?"* FOUNDRY TRADE JOURNAL, May 23, 1946, vol. 79, no. 1553, pp. 83-87, 92.

The author discusses ways in which a pattern shop can function as an asset to a foundry.

Sand

CONTROL. *"Malleable Sand Control,"* AMERICAN FOUNDRYMAN, January, 1946, vol. 9, no. 1, pp. 42-47.

A summary of answers to a questionnaire on malleable sand control.

CONTROL. Morey, R. E., and Taylor, H. F., *"Use of the Cumulative Curve for Foundry Sand Control,"* AMERICAN FOUNDRYMAN, January, 1946, vol. 9, no. 1, pp. 65-75.

A critical study of methods used to determine particle size of granular materials and an evaluation of the cumulative curve as a means of indicating grain size characteristics.

The authors feel that the use of the cumulative curve for molding sands would be superior to the present standard methods for indicating distribution.

GRAY IRON FOUNDRY. *"Gray Iron Foundry Sands,"* AMERICAN FOUNDRYMAN, April, 1946, vol. 9, no. 4, pp. 143-147.

An account of the efforts of the Subcommittee on Physical Properties of Gray Iron Foundry Sands at Elevated Temperatures to develop a test method whereby the shakeout effort required to remove cores from castings could be measured by a quick laboratory test.

HOT STRENGTH. Dietert, H. W., *"Effect of Table Rise (Strain Rate) on Hot Strength of Bentonite Bonded Sands,"* AMERICAN FOUNDRYMAN, January, 1946, vol. 9, no. 1, pp. 78-79.

The author states that in hot strength tests the application of a load under conditions of constant stress is preferable to the application of a load under conditions of constant strain.

He describes the conditions under which hot strength is determined and lists advantages of the rate of loading which he has selected.

PROPERTIES. Parker, Wm. G., *"Some Aspects of Green Deformation and Sand Toughness in Sand Control,"* AMERICAN FOUNDRYMAN, January, 1946, vol. 9, no. 1, pp. 50-54.

Mixing efficiency and workability control are sand factors which directly affect the amount of foundry scrap and machining time. Important aids in maintaining these factors are deformation and sand toughness number determinations. These determinations are described.

Steel

GERMAN. Briggs, Charles W., *"The German Steel Casting Industry,"* STEEL, April 15, 1946, vol. 118, no. 15, pp. 94-96, 118, 120.

A summary of the various steel-making methods used in Germany during the war. Many times, which before the war were fabricated by other methods, were cast from steel.

HOT TEAR. Gelperin, N. B., *"Steel Susceptibility to Hot-Tear Formation in Castings,"* AMERICAN FOUNDRYMAN, April, 1946, vol. 9, no. 4, pp. 161-163.

Various steels are quite different in their susceptibility to hot-tear under similar conditions. The tendency toward hot-tear formation is influenced by the allotropic transformation of delta phase to gamma phase, which takes place during cooling of castings in most steels.

Firm Facts

D. D. Foster Co., Pittsburgh, Pa., has been appointed district representative for the products of **Hammond Iron Works**, Warren, Pa.

Welding activities of **American Car & Foundry Co.**, New York, have led to establishment of a Welded Products Division.

Chicago Flexible Shaft Co., Chicago, has adopted a new firm name, **Sunbeam Corp.**, and has renamed the former **Stewart Industrial Furnace Division; Sunbeam Industrial Furnace Division.**

Baltimore, Md., lead burning equipment of **Andrews Lead Construction Co.**, Long Island City, N. Y., subsidiary of **American Smelting & Refining Co.**, New York, has been moved to the rear of the plant of **American Electric Welding Co.**, Baltimore.

In the interest of establishing identity with it wholly-owned subsidiary, **Robins Conveyors, Inc.**, Passaic, N. J., the firm name of **Hewitt Rubber Corp.**, Buffalo, N. Y., has been changed to **Hewitt-Robins, Inc.** Plant at Passaic has been designated as **Robins Conveyors Division.**

At recent ceremonies commemorating the 50th anniversary of founding of the original company, 159 employees of the division were presented with service pins in recognition of association ranging up to 40 years; Thomas Robins, founder of the organization, was presented with an historical memento, a scale model of a conveyor he exhibited at the Paris Exposition of 1900; and Thomas Robins, Jr., president, outlined expansion plans, which include immediate construction of a large plant of the latest design and equipment.

The Delhi Foundry Sand Co., Cincinnati, has recently completed the addition of a dry milling and screening plant to its facilities.

Holub Industries, Inc., a new concern organized by B. E. Holub, has begun manufacture of electrical and

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Firm Facts

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mechanical products in its new plant at 413 DeKalb Ave., Sycamore, Ill. Mr. Holub resigned as general sales manager, **Ideal Industries,** Sycamore, after an association of 24 years with the company, in order to establish the new firm. G. W. Wetzel, assistant to Mr. Holub at Ideal Industries and recently released after 39 months' service with the armed forces, assumes the position of sales manager, Holub Industries.

Atlas Lumnite Cement Co. has been merged with the **Universal Atlas Cement Co.,** New York, and will be known as the **Lumnite Division** of that firm. Both organizations are wholly owned subsidiaries of **United States Steel Corp.**

Engineering Service of America, Inc., Detroit, announces location of its western office at 406 E. Colorado Ave., Glendale, Calif.

Manhattan Rubber Div., Raybestos-Manhattan, Inc., Passaic, N. J., honored its veteran employees May 26, with a dinner at Mountainview, N. J., attended by nearly 500 "Pioneers" and their wives or husbands. Fourteen employees with 25 years service with the company were introduced as new Pioneers; three 50-year Pioneers were saluted and presented with gold pins adorned with five diamonds; and approximately 300 others received gold pins with a diamond for each five years of service over twenty-five.

Joining the ranks of 50-year Pioneers were C. T. Young, A. J. Gibson and John Dotterweich, who received their insignia at the hands of J. F. D. Rohrbach, executive vice-president and treasurer. J. H. Mathews, assistant general manager, introduced the Pioneers of 1946, and also handled presentations to the various year groups.

Coaltoter Conveyor Co. (Not Inc.), Chicago, has changed the firm name to **Material Movement Industries.** Horton Conrad, managing partner, states that the change was made in order to portray more accurately the scope of the firm activities and equipment.